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Background and data inputs for models evaluated as part of the 2015 southern Gulf of St. Lawrence fall-spawning herring assessment framework review

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

Herring in the southern Gulf of St. Lawrence (sGSL; NAFO 4T) are comprised of two stocks, one that spawns in the spring and the other in the fall. The March 2014 peer review meeting of the assessment of sGSL fall spawning herring identified issues with the indices of abundance from the gillnet fishery and with the assessment model. A framework review of the assessment approach was recommended to address the identified shortcomings and to review alternative model formulations. The framework review, which took place April 13 to 15, 2015, also considered two suites of assessment models; ones for the NAFO 4T area as a whole, as per past practice, and ones that treated the 4T stock as being comprised of three regional stocks (North, Middle and South regions). The regionally-disaggregated assessment models were considered in response to numerous past requests by commercial fall herring gillnet harvesters and fisheries managers from Fisheries and Oceans Canada. In this report we describe the sources of information, the data, and the indices considered for both the whole area and regionally-disaggregated assessment models. These include the traditional inputs to past assessment models for sGSL fall spawning herring, such as catches-at-age and catch-per-unit-effort indices, and new indices developed for the framework meeting, including indices based on index gillnet catch rates and catches in the multi-species bottom-trawl survey of the sGSL.

Renseignements de base et données d'entrées pour les modèles évalués lors de l'examen de 2015 du cadre d'évaluation du stock de harengs reproducteurs d'automne du sud du golfe du Saint-Laurent

RÉSUMÉ

Les populations de hareng dans le sud du Golfe du Saint-Laurent (sGSL; division 4T de l'OPANO) sont composées de deux stocks reproducteurs, un de printemps et un d'automne. Au cours de la réunion d'examen par les pairs de mars 2014 sur l'évaluation du stock de harengs reproducteurs d'automne du sGSL, on a relevé des problèmes avec les indices de l'abondance provenant de la pêche au filet maillant ainsi qu'avec le modèle d'évaluation. Un examen du cadre de l'approche d'évaluation a été recommandé pour combler les lacunes repérées et examiner d'autres formules de modèle. L'examen du cadre, qui s'est déroulé du 13 au 15 avril 2015, portait également sur les deux séries de modèles d'évaluation; celle considérant la zone de la division 4T de l'OPANO dans son ensemble, comme par le passé, et celle étudiant le stock de la division T comme étant composé de trois stocks régionaux (régions du nord, du centre et du sud). Les modèles d'évaluation divisés par région ont été élaborés en réponse aux nombreuses demandes des pêcheurs commerciaux au filet maillant du hareng d'automne et des gestionnaires des pêches de Pêches et Océans Canada. Dans le présent rapport, nous décrivons les sources de renseignements, les données et les indices pris en compte à la fois par les modèles d'évaluation considérant la zone dans son ensemble et les modèles divisés par région. Ceux-ci comprennent les données d'entrées traditionnelles des modèles d'évaluation passés du stock de harengs reproducteurs d'automne du sGSL, comme les indices de prises selon l'âge et de prises par unité d'effort, et de nouveaux indices élaborés pour la réunion sur le cadre, y compris des indices dérivés d'un indice provenant des taux de prises au filet maillant et des prises dans les relevés plurispécifiques au chalut de fond du sGSL.

1. BACKGROUND

Atlantic herring (*Clupea harengus*) in the southern Gulf of St. Lawrence (sGSL) is found in the area extending from the north shore of the Gaspé Peninsula to the northern tip of Cape Breton Island, including the Magdalen Islands. Adults overwinter off the north and east coast of Cape Breton in the Northwest Atlantic Fisheries Organization (NAFO) divisions 4T and 4Vn (Claytor 2001; Simon and Stobo 1983). Studies in the early 1970s indicated that sGSL herring also overwintered off the south coast of Newfoundland, but an exploratory fishery in 2006 found no concentrations there (Wheeler et al. 2006). The sGSL herring is harvested primarily by an inshore gillnet fleet (fixed gear) and a purse seine fleet (mobile gear), both fishing in the NAFO division 4T and in some years in 4Vn (Fig. 1). During the spring and the fall fishing seasons, seiners are prohibited from fishing in several areas set aside exclusively for the gillnet fleet (Claytor et al. 1998). Both spring and fall spawner components of herring are harvested in these fisheries. The percentage of spring and fall spawner components in the catch varies according to season and gear type. As a result, landings during the spring and fall fisheries must be separated into the appropriate spring and fall spawning groups to determine if the Total Allowable Catch (TAC) for these groups has been attained (details in LeBlanc et al. 2015).

The spring and fall spawning components of 4T herring are considered distinct stocks which are assessed separately. The March 2014 peer review meeting of the assessment of fall spawning herring in the sGSL identified issues with the indices of abundance from the gillnet fishery and the assessment models. Two assessment models that varied in the assumptions about catchabilities in the gillnets gave biomass estimates that differed substantially between models, although the trends in abundance from both models were very similar (DFO 2014). Neither model was deemed to provide a suitable representation of stock dynamics, as both produced unacceptable patterns in residuals for the abundance indices as well as large retrospective patterns. A framework review of the assessment approach was recommended to address the identified shortcomings and to review alternative model formulations.

Commercial fall herring gillnet harvesters and fisheries managers from Fisheries and Oceans Canada have routinely requested that assessment models be attempted for sub-regions of the stock. Herring show high spawning site fidelity (Wheeler and Winters 1984; McQuinn, 1997; Brophy et al. 2006), raising the possibility of local stocks within sub-regions. These local stocks are targeted by the gillnet fishery which takes place on the spawning grounds. Even if stock dynamics are not local to sub-regions, the possibility of differences in fishing patterns and fishery catchability between regions means that treating regions separately, at least to some degree, may lead to a more accurate assessment of the 4T stock. Regionally-disaggregated assessment models were therefore considered as part of the framework review.

2. DATA INPUTS FOR THE ASSESSMENT MODELS

Two general sets of assessment models were evaluated for the fall spawning herring stock as part of the assessment framework review: whole area models (NAFO 4T) and regionally-disaggregated models covering sub-regions of NAFO 4T. The regionally-disaggregated models were for three regions which jointly cover the entire area and which are defined on the basis of traditional herring spawning beds and fishing areas: north (Gaspé and Miscou; 4Tmnopq), middle (Escuminac-Richibucto and west Prince Edward Island; 4Tl), and south (Fisherman`s Bank and Pictou; 4Tfghj) (Fig. 2). The choice of three regions was dictated by geographic proximity of spawning beds and is the finest level of disaggregation that can presently be supported by the available data. The regionally-disaggregated models include inputs that are

region specific (e.g., catch-at-age, catch-per-unit-effort) and inputs that are common to the entire area (e.g., acoustic survey index, size-at-age).

When calculating region-specific catch-at-age, catches made by herring seiners during the fall were attributed to the region in which they were made, while catches made during the late spring and summer were attributed to the south region, which is most proximate to the location of capture. Prior to 1999 there was a winter fishing in NAFO 4Vn that targeted herring on their overwintering grounds, when herring from different sub-areas are presumably aggregated together. Catches made during that winter fishery were attributed to the regional catches in proportion to the regional catches for that same year.

This document presents the most up-to-date assessment inputs available for fall-spawning sGSL herring. Many details on derivation of these inputs were routinely presented in past assessment research documents and are not repeated here (see LeBlanc et al. 2015 for details). This document also will not present the information on herring that is not included in the model or used to formulate science advice concerning the stock or fishery.

2.1 SOURCES OF INFORMATION

2.1.1 Telephone survey

A telephone survey of commercial herring harvesters has been conducted annually since 1986 to collect information on the gillnet fishery and opinions on abundance trends (details in LeBlanc and LeBlanc 1996). Active commercial licence holders were asked a series of questions concerning the number, dimensions and mesh size of nets they used, the frequency of fishing, and how the abundance in the current year compared to the previous year and the medium-term trend. Responses related to the nets and fishing frequency were used to determine fishing effort. For the 2014 gillnetter telephone survey, 172 candidates were randomly selected out of approximately 665 active commercial licence holders for both seasons. Of these 172 candidates, 151 responded to the questionnaire, including 27 spring gillnetters and 124 fall gillnetters.

2.1.2 Landings

Catch data were taken from purchase slips and ZIFF (zonal interchange file format) files collected by Statistics Branch. Catch data up to 1985 are available by fishery (fixed and mobile) and fishing area. Beginning in 1986, the catch data are further reported by vessel and trip.

2.1.3 Fishery sampling

Commercial fishery catches are sampled dockside by DFO scientific personnel for the gillnet and seiner fisheries, and at sea by fisheries observers in the seiner fishery. The samples are used to determine the size, age and spawning stock (spring or fall) composition of the catch. Sampling procedures are such as to obtain samples that are spatially and temporally representative of landings in each of the fixed and mobile gear fisheries. The composition of landings is inferred using the sampling results for each principal fishing area and season, and where it is warranted, also on a finer time scale (weeks). The landings and samples by area that were used to calculate catch-at-age in the fall fishery for 2014 are described in Table 1.

2.1.4 Experimental nets

Experimental gillnets, consisting of multiple panels of varying mesh size, were fished approximately weekly by fishermen participating in a hydro-acoustic study on fall spawning grounds from 2002-2014 (Surette et al. 2016). The original intention was to use the catches to

calibrate the signal strength from the hydro-acoustics in order to obtain nightly estimates of spawning biomass in the various regions. A harvester from each of five spawning grounds participated in the study: Miscou Bank (North region), Escuminac (Middle), West PEI (Middle), Fisherman's Bank (South) and Pictou (South). Each experimental gillnet had five panels, each with a different mesh size, from a set of seven possible mesh sizes, ranging from 2" to $2^{3}/_{4}$" in $^{1}/_{8}$" increments. All gillnets had panels with mesh sizes of $2^{1}/_{2}$", $2^{5}/_{8}$", and $2^{3}/_{4}$", plus two smaller mesh sizes that varied among harvesters. The target fishing procedure was a one hour soak and nets were set during the commercial fishery on the fishing grounds. For this framework assessment, catches from the experimental nets project have been used to estimate the relative size-selectivity of gillnets of different mesh sizes and to produce age-disaggregated abundance indices (details in Surette et al. 2016). Both are inputs to the revised assessment model.

2.1.5 Acoustic survey

Since 1991, an annual fishery-independent acoustic survey of early fall (September-October) concentrations of herring in the southern Gulf has been conducted. The standard annual survey area occurs in the Chaleurs-Miscou area, though in some years the survey has also covered waters north of PEI. The survey design uses random parallel transects within predefined strata, and employs two vessels: an acoustic vessel to quantify the biomass of fish schools using a hull-mounted 120 KHz single beam transducer, and a fishing vessel to sample aggregations of fish with a pelagic trawl (LeBlanc and Dale 1996; LeBlanc et al. 2015). The samples are used to separate the observed biomass by spawning stock and age. The acoustic survey in 2014 covered a total transect distance of 1,128 km within the Chaleurs-Miscou area (Appendix Fig. A1). Appendix Figure A2 shows the distribution of estimated herring schools during the 2014 survey.

2.1.6 Multispecies bottom-trawl survey

The annual multi-species bottom trawl survey, conducted each September since 1971, provides information on the abundance and distribution of 4T herring throughout the sGSL in September (Benoît et al. 2009; Savoie 2014). Total catch weights and numbers, a representative length frequency, and representative individual length-weight data have been recorded for each fish species in each survey set since 1971. Since 1994, additional sampling of herring catches has been undertaken to disaggregate catches by spawner group and age. Additional details of this survey are in Hurlbut and Clay (1990).

2.2 DATA AND INDICES

2.2.1 Catch at age and weight at age

Catch-at-age and weight-at-age matrices for the 4T herring fall spawner component were derived using age-length keys and length-weight relationships for each principal fishing area, gear type, and season. Catch-at-age and weight-at-age for the entire fall spawner fishery are presented separately for fixed gear (Table 2) and mobile gear (Table 3). Weight-at-age for both fleets during the fishery and at the beginning of the year are presented in Tables 4 and 5 respectively.

Inshore gillnet fleet catches of the fall spawning component in 2014 were dominated by the 2007 year-class (age 7 in 2014) and the 2006 year-class (age 8 in 2014). The weights-at-age for the whole area were assumed to apply to each of the three regions, given little evidence of regional differences.

Region-specific catches-at-age are presented separately for fixed gear (Table 6) and mobile gear (Table 7), and for both gears combined (Fig. 3).

2.2.2 Changes in catchability to the gillnet fishery

There are at least two factors that are likely to have affected the catchability of herring to the gillnet fishery, namely changes in size-at-age and changes in the mesh sizes used by harvesters. As described below, both have varied in time for the fall fishery.

The retention of herring that contact gillnets is likely to be mainly a function of mesh size and the girth of individual fish. However, girth is not routinely measured during the sampling of herring and a proxy was therefore required for estimating changes in the relative catchability of herring. Girth was measured for a subset of herring sampled as part of routine catch sampling in 2014, covering the range of ages, maturity stages and for each sex. Girth was found to be linearly related to both length and weight (Fig. 4). The relationship with weight was stronger (R^2=0.84), compared to that with length, for which there was also a logical dependency on maturity stage (R^2 = 0.47). When only the maturity stages caught in the gillnet fishery were considered (stages 5 and 6), the relationship with length was stronger (R^2 = 0.58). Though length is still a weaker proxy for girth compared to weight, this confirms its utility in estimating possible changes in selectivity. This is important because lengths are the basic unit of measurement for sampling and are the size measure used in estimating relative selectivities for experimental nets (Surette et al. 2016a) and in estimating catches-at-age.

Lengths-at-age in the fishery have been declining steadily since 1978 for all ages, with an average decrease on the order of around 20% to 2014 (Fig. 5). Since 1990, the mobile gear fleet has caught herring with lower lengths-at-age, particularly for younger herring. Comparisons between regions in the trends in length-at-age are only possible for herring sampled from gillnet catches. There were no apparent differences between regions. A common set of lengths-at-age was therefore used to estimate changes in catchability for the CPUE indices (1986-2014). For ages and years for which there were differences between fixed and mobile gear, lengths for the mobile gear were used as they are assumed to be less affected by gear selectivity (Fig. 5, bottom right panel). Results from all gears combined were used otherwise.

In the fall gillnet fishery, $2^5/_8$" mesh has been the most common and has been the minimum legal mesh size since 1993. Beginning in 1992, many harvesters started using larger mesh sizes ($2^3/_4$") but by 2002, the proportion of $2^5/_8$" mesh reverted to pre-1992 values. The proportion since 2008 has been between 94% and 99% (Fig. 6). Though the trend has been largely the same throughout the sGSL, there were regional differences in proportions.

Based on an analysis of experimental net catches, Surette et al. (2016a) estimated the size-dependent relative selectivity of herring as a function of mesh size. Using the regional relative compositions of mesh sizes (Figure 6) and the available information on the annual size-at-age of herring, overall annual gillnet fishery relative age-dependent selectivities were estimated for each region. These selectivities integrate the effects of changes in length-at-age and changes in mesh size used (Fig. 7). In all regions these changes have resulted in an estimated decline in selectivity over time for the younger fish and little trend in selectivity for the oldest fish. The magnitude of decline for the younger fish (e.g. ages 4-6) appears to be substantial.

2.2.3 Abundance indices

2.2.3.1 Catch-per-unit effort

Gillnet catch and effort data were used to construct age-disaggregated abundance indices for fall spawning 4T herring, based on catch-per-unit effort (CPUE). The gillnet fisheries take place on the spawning grounds and generally account for more than 90% of the fall spawner catch.

Catch data were taken from the landings data. Effort was calculated as the number of trips (purchase slips) multiplied by the estimated number of standard net hauls, which were determined from the annual telephone survey of active herring harvesters and, since 2005, also from dockside observer data, where available. This information on effort is available since 1986.

The percent of gillnet fishing days with no catch has been recorded for the past eight years based on responses to the telephone survey (Table 8). The 2014 percentages of gillnet fishing days with no catch are the highest in the time series for the fall gillnet fishery. Unfortunately because this information is available only for the most recent period, it is not presently included in the calculation of fishing effort. Furthermore, uncertainty about how the question is interpreted by respondents was raised during the assessment framework meeting, and a recommendation to revise the question for future telephone surveys was made.

The current gillnet CPUE indices are defined as catches in kg/net-haul/trip. Age-specific CPUE indices for ages 4-10 have been used in recent assessments for the stock, as is done here. The indices as presented here account only for catch and effort, and do not account for possible changes in selectivity/catchability, which are addressed as part of the population modelling.

A multiplicative model (GLM) is used to calculate the standardized indices, based on the following formulation:

$$\ln(CPUE_{ijk})=\alpha+\beta_1 I+\beta_2 J+\beta_3 K+\epsilon$$

where I indexes year, J indexes area (statistical district), K indexes week and ϵ is the residual error. This model was applied to the data for the whole stock area. Separate GLMs of this form, but excluding the area term, were estimated for each of the three regions separately. The analysis in each case was restricted to weeks 27 to 43.

The model for the stock area explained 43% of the variance in the data and the factors for year, area and week were all statistically significant (Table 9). Estimated values of the CPUE for the whole area are presented in Table 10. Overall, there are recent declines in the CPUE of younger herring (ages 4-6), with some increases for older herring.

The models for each region explained between 54% and 67% of the variance in catch rates depending on the region (Table 9). The terms for year and week were significant in each case (Table 9) and plots of the original data confirm a consistent pattern across years in catch rates over the weeks of the fishery (Appending Fig. A3). Furthermore, patterns in the model residuals do not suggest any strong model misspecification (Appending Fig. A4). Estimated region-specific values of the CPUE values are presented in Table 11 and in Figures 8 and 9. These also suggest current decreases in the CPUE of younger fish and increases in the CPUE of older fish in all regions. However, the declines in younger fish have been more pronounced in the South region.

The ability of the CPUE indices to track cohorts (internal consistency) was assessed by correlating abundance at age in a given year with abundance at the next age in the following year. Correlation values were reasonable for all ages, both on a region-specific basis and for the sGSL overall (Table 12).

2.2.3.2 Experimental nets indices

Surette et al. (2016a) estimated standardized experimental net age-disaggregated catch rates based on a 1-hr soak time using the data from the experimental net catches and a mesh selectivity model. These estimates account for length-dependent changes in catchability. Estimates were produced by region, though there were no values for the North region in 2007 and 2013 and the Middle region in 2002 (Table 13; Fig. 10). Furthermore, there were few useful catches for the Middle region in 2010, rendering the use of the estimated value for that year questionable. The indices suggest that there may have been an increase in herring abundance in the North, no strong trend in the Middle region, and an overall decline in the South region, particularly at younger ages (Fig. 10). Internal consistency for the indices is good for a number of regions and ages, but was low in some instances such as for ages 5 to 7 in the Middle and South regions (Table 14).

An overall experimental net abundance index at age for NAFO 4T was calculated as an average of region specific values weighted by regional catch-at-age (Table 15; Fig. 11). This index appears to track abundance well for 3 to 5 year old fish and 7 to 10 year olds (Table 14). It suggests an increase in young herring (2 to 4 year olds) to around 2009, followed by a decline, and no major trend over time for older ages (Fig. 11).

2.2.3.3 Acoustic survey

The age-disaggregated acoustic abundance index for ages 2 to 9 for 1994 to 2014 is presented in Table 16. However, the acoustic survey is assumed to provide a useful index of abundance only for recruiting herring (ages 2 and 3; LeBlanc et al. 2015). It is not thought to provide a useful abundance index for older ages given that the survey is limited to a restricted portion of the sGSL at a time when older herring are in areas throughout the sGSL spawning. In the previous assessment (LeBlanc et al. 2015), a fall spawner index of abundance for ages 2 and 3 from the acoustic survey was included in the population model, used as an age-disaggregated juvenile abundance index (Fig. 12). This index suggests that the abundance of two year olds was relatively high in 2014, up from one of the lowest values the year previous. In contrast, the abundance of three year-olds in 2014 was still below average, though greater than in 2013.

2.2.3.4 Multi-species bottom-trawl survey

Catches of herring in the bottom-trawl survey can be quite variable, even within areas where herring are common (e.g., see Savoie 2014). Nonetheless, Surette (2016) estimated catch rates at age (mean number per tow) of fall spawning herring in the multi-species trawl survey using a Bayesian estimation model (Table 17). The internal consistency of those age-disaggregated indices for 1994-2011 was assessed at a one-year lag using correlation analysis (Fig. 13). Correlations were felt to be sufficiently strong only for catches of herring ages 4 ($r = 0.13$ or $r = 0.51$ when an outlying catch is removed), 5 ($r = 0.49$ or $r = 0.36$ when the same influential outlying catch is removed) and 6 ($r = 0.61$).

The indices suggest an increasing trend in four year old herring from the mid-1990s to 2010, and generally higher abundance of six year old herring in the 2000s compared to the 1990s (Fig. 14). McQuinn (2009) has suggested that increases in herring catches in bottom-trawl surveys may largely result from an increased association of herring with the sea floor, possibly as a result of decreased predation pressure by collapsed groundfish populations. Increased survey catches would therefore be a function of increased catchability to the gear and not a result of an abundance increase. However, there does not appear to have been a trend towards closer association of herring with the bottom in the sGSL, based on observations from the acoustic survey (Fig. 15). There are therefore no reasons to believe that the observed increases in the abundance indices reflect changes in catchability.

2.3 OTHER INPUTS

2.3.1 Maturity ogive

For the purposes of the assessment, herring are assumed to follow a knife-edged maturity schedule, with 100% maturation occurring between the ages of 3 and 4 (Table 18) (LeBlanc et al., 2015).

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TABLES

Table 1. Fall fishery samples and landings by zone used to derive the 2014 catch and weight-at-age matrices for 4T herring.

Gear/ Region	Fishery 2014	Zone	Samples	Landings (t)
Fixed Gear - Gillnets				
North	Gaspe (16A) fall	4Topq	1	2.6
North	Chaleur (16B) July – August 15	4Tmn	2	1759.4
North	Chaleur (16B) August 16 - 22	4Tmn	3	4232.4
North	Chaleur (16B) August 23 +	4Tmn	5	7344.4
Middle	Escuminac – West P.E.I. (16CE) July – August	4Tl	5	1888.7
Middle	Escuminac – West P.E.I. (16CE) Sept. 1 - 5	4Tl	3	2286.0
Middle	Escuminac – West P.E.I. (16CE) Sept. 6 +	4Tl	1	890.3
South	Magdalene Islands (16D) fall	4Tf	1	158.0
South	East P.E.I. (16G)) July – Sept. 19	4Tgj	3	1135.2
South	East P.E.I. (16G) Sept. 20 +	4Tgj	6	1322.5
South	Pictou (16F) fall	4Th	3	5029.4
Fixed gear total		4T	33	25910.0
Mobile Gear – Purse seines				
South	Spring Edge fishery – June	4Tf	5	1941.0
North	East of Grande-Anse (16B) Oct.	4Tmn	8	874.4
North	East of Grande-Anse (16B) Nov.	4Tmn	8	1029.4
Mobile gear total		4T	21	3844.8

Table 2a. Fall spawner catch-at-age (in thousands) for the 4T herring fixed gear fishery of Atlantic herring of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	41	2241	5405	3831	885	949	4833	80	140	2341	20746
1979	910	16	579	11579	5711	2864	724	1036	915	322	632	25288
1980	0	64	7884	4374	6283	1105	2348	484	556	409	173	23679
1981	0	66	6095	24399	6935	2792	1231	1217	172	281	322	43510
1982	0	0	2108	14307	16990	5183	2815	1137	396	121	129	43186
1983	0	0	821	20721	10277	13817	2380	1808	573	63	263	50723
1984	0	0	891	24352	15093	8985	6422	1574	571	230	101	58218
1985	0	0	199	6555	29974	15570	8683	7684	2542	746	35	71989
1986	0	383	1535	31954	16807	36455	19831	9356	4014	580	980	121895
1987	0	16	8641	36322	29218	20947	36964	15570	10053	4562	2100	164393
1988	0	0	1346	21922	44378	21681	14350	15582	8043	2998	2618	132919
1989	0	0	332	14260	23308	30767	15186	6947	8752	3449	2557	105557
1990	0	14	3446	22450	20679	28712	59355	18217	10181	10648	6677	180380
1991	0	0	160	39661	10594	8060	10947	13617	5100	2963	5036	96137
1992	0	0	23	11368	54218	13042	7389	8589	9518	4219	6988	115355
1993	0	0	82	2703	30919	36647	5829	2921	2977	1513	2551	86142
1994	0	0	0	8866	12217	48466	70721	12083	9869	8923	14875	186021
1995	0	0	24	3853	41867	17237	51184	49433	9090	6467	15099	194254
1996	0	0	4	19658	19632	46515	10509	23236	23961	4955	10878	159349
1997	0	0	1106	17513	64208	13459	21133	3890	6859	6469	3968	138605
1998	0	0	59	23256	32702	47339	11459	17637	3134	5994	8757	150336
1999	0	0	265	38385	68890	39101	23455	5285	7283	1792	3441	187895
2000	0	0	356	36338	108837	41591	11871	8524	1797	2010	1105	212429
2001	0	0	954	30198	64970	60448	21007	4671	2361	608	1345	186562
2002	0	1	487	48068	38902	40482	29832	7787	1927	1543	951	169979
2003	0	0	419	22302	78098	28410	28940	26198	5985	1884	1485	193722
2004	0	0	16	34187	39004	40265	15157	13024	7602	2158	921	152334
2005	0	0	3	7813	83076	54562	44002	13856	11128	4652	635	219729
2006	0	0	55	10615	53320	70794	31427	19658	9990	5392	1885	203137
2007	0	0	716	6563	27935	57737	58441	24205	7408	4559	1953	189518
2008	0	0	2121	35457	16066	29793	32568	38194	10187	5695	4015	174097
2009	0	0	1044	33189	73772	24332	38549	16509	6561	6072	3108	203137
2010	0	0	8	6729	46907	72132	21275	20052	13468	6681	3282	190533
2011	0	0	1	2374	16006	46398	65128	13825	9407	7301	5589	166029
2012	0	0	16	328	11743	39265	52590	35524	4929	3751	3001	151147
2013	0	0	21	1984	11157	45238	50921	24418	8231	494	254	142719
2014	0	0	0	264	9785	14595	39702	35982	12555	2629	96	115608

Table 2b. Fall spawner weight-at-age (kg) for the 4T herring fixed gear fishery of Atlantic herring of the southern Gulf of St. Lawrence.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	na	0.077	0.141	0.243	0.286	0.318	0.341	0.377	0.394	0.396	0.447
1979	0.023	0.132	0.194	0.249	0.289	0.337	0.372	0.397	0.421	0.436	0.467
1980	na	0.212	0.207	0.254	0.321	0.373	0.347	0.407	0.479	0.464	0.510
1981	na	0.183	0.221	0.261	0.318	0.371	0.415	0.428	0.458	0.469	0.497
1982	na	na	0.224	0.269	0.304	0.338	0.378	0.382	0.398	0.385	0.481
1983	na	na	0.192	0.257	0.289	0.320	0.349	0.374	0.372	0.425	0.434
1984	na	na	0.233	0.247	0.290	0.322	0.349	0.399	0.414	0.403	0.506
1985	na	na	0.212	0.253	0.292	0.335	0.363	0.385	0.413	0.438	0.466
1986	na	0.175	0.202	0.249	0.299	0.329	0.373	0.391	0.404	0.444	0.451
1987	na	0.175	0.236	0.249	0.282	0.320	0.347	0.374	0.392	0.392	0.431
1988	na	na	0.235	0.265	0.293	0.330	0.359	0.393	0.420	0.425	0.454
1989	na	na	0.224	0.257	0.296	0.326	0.354	0.382	0.393	0.417	0.430
1990	na	0.148	0.196	0.245	0.284	0.325	0.348	0.370	0.394	0.409	0.433
1991	na	na	0.193	0.231	0.266	0.301	0.336	0.354	0.373	0.395	0.414
1992	na	na	0.199	0.224	0.255	0.282	0.310	0.343	0.352	0.365	0.406
1993	na	na	0.172	0.221	0.240	0.267	0.291	0.332	0.350	0.352	0.392
1994	na	na		0.210	0.238	0.260	0.289	0.320	0.345	0.360	0.388
1995	na	0.103	0.184	0.207	0.231	0.251	0.281	0.301	0.339	0.364	0.386
1996	na	na	0.172	0.221	0.245	0.259	0.285	0.309	0.329	0.365	0.396
1997	na	na	0.176	0.206	0.235	0.263	0.277	0.313	0.330	0.345	0.400
1998	na	na	0.159	0.212	0.234	0.259	0.285	0.297	0.327	0.343	0.373
1999	na	na	0.164	0.211	0.237	0.251	0.278	0.303	0.323	0.356	0.373
2000	na	na	0.171	0.212	0.233	0.259	0.278	0.305	0.328	0.350	0.377
2001	na	na	0.170	0.210	0.234	0.253	0.275	0.302	0.321	0.347	0.377
2002	na	na	0.189	0.219	0.240	0.258	0.280	0.295	0.319	0.322	0.356
2003	na	na	0.163	0.208	0.232	0.255	0.271	0.292	0.312	0.334	0.352
2004	na	na	0.146	0.202	0.223	0.243	0.263	0.285	0.303	0.314	0.347
2005	na	na	0.188	0.198	0.225	0.238	0.250	0.273	0.285	0.295	0.326
2006	na	na	0.177	0.201	0.222	0.240	0.253	0.263	0.287	0.293	0.310
2007	na	na	0.151	0.198	0.204	0.224	0.239	0.247	0.261	0.269	0.291
2008	na	na	0.130	0.179	0.213	0.224	0.237	0.247	0.252	0.265	0.284
2009	na	na	0.151	0.187	0.202	0.231	0.246	0.260	0.270	0.269	0.269
2010	na	na	0.139	0.173	0.205	0.215	0.237	0.253	0.262	0.280	0.290
2011	na	na	0.119	0.178	0.188	0.214	0.221	0.247	0.261	0.263	0.274
2012	na	na	0.121	0.157	0.182	0.200	0.214	0.222	0.245	0.255	0.275
2013	na	na	0.135	0.163	0.193	0.201	0.213	0.227	0.232	0.267	0.274
2014	na	na	na	0.172	0.196	0.216	0.221	0.227	0.242	0.240	0.297

Table 3a. Fall spawner catch-at-age (in thousands) for the 4T herring mobile gear fishery of Atlantic herring of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	1351	21407	23331	21495	4337	5052	15023	1844	1268	17790	112898
1979	156	5951	8965	7073	4946	7233	2077	3241	3851	1660	11889	57042
1980	151	2944	41338	15803	21870	10293	4861	1793	2584	1745	1850	105231
1981	18	1118	10011	11787	1076	297	447	31	187	0	0	24972
1982	0	1018	8889	3585	6962	841	135	156	104	26	263	21978
1983	0	222	5708	6865	2643	4141	720	167	224	30	91	20811
1984	0	398	1075	4824	4988	2748	1795	386	88	11	39	16353
1985	0	331	1904	2489	7414	6556	2955	2205	1837	574	0	26263
1986	0	347	2524	2619	3115	5966	3526	1565	1614	208	218	21701
1987	0	1633	3373	2290	1037	1337	3663	3895	871	870	373	19342
1988	98	3951	2499	2766	3249	1559	3239	2822	1074	1402	1629	24288
1989	0	828	1073	2202	4390	4541	1899	2252	2706	1557	1182	22630
1990	0	71	4463	3357	3653	2019	1981	1549	2084	988	296	20461
1991	0	0	5138	18139	4009	1188	1942	1452	382	712	2282	35246
1992	0	44	662	5408	13353	3001	2043	1442	1695	1330	4868	33846
1993	0	311	4383	2693	4587	7513	2282	1874	1767	2377	3285	31072
1994	0	15	287	8493	3669	10253	13275	1696	1803	1365	2728	43584
1995	0	22	2365	3798	20405	6426	9793	10346	2030	943	2486	58614
1996	0	389	2713	13239	5743	10708	4085	3218	2094	830	1082	44103
1997	0	429	4878	6312	9862	2434	4615	899	1380	788	916	32512
1998	0	51	1553	3198	3528	3734	737	2408	340	1088	1268	17905
1999	0	713	8064	12841	9250	4870	5969	2899	2228	643	1345	48821
2000	0	1029	6801	12522	12091	3670	1740	1041	306	320	254	39774
2001	146	2026	12826	7415	9713	8790	2662	1827	1064	250	330	47050
2002	0	1030	4482	14029	11196	9305	7609	1910	552	802	394	51310
2003	0	201	8565	15653	11982	7392	7828	7594	2503	852	675	63246
2004	0	519	4592	15304	6675	4522	2932	2145	1778	506	333	39306
2005	0	956	4466	17820	14883	4929	1228	684	674	271	154	46063
2006	0	1042	2355	3670	8741	5832	1575	519	330	242	54	24359
2007	0	1491	15237	5020	2838	3437	1735	511	108	46	23	30447
2008	0	1385	8080	5566	1678	834	607	771	3	24	0	18948
2009	0	179	4648	5917	2313	295	211	51	5	0	0	13618
2010	11	6	1875	7040	10603	7199	1296	705	208	90	1	29033
2011	0	1177	749	2101	2304	2477	1015	368	8	59	6	10263
2012	0	42	379	354	1142	1054	559	342	56	14	7	3949
2013	17	545	447	4406	3940	5880	6444	2661	2111	220	103	26775
2014	0	36	1780	1092	5580	2992	3781	2913	1445	356	0	19975

Table 3b. Fall spawner weight-at-age (kg) for the 4T herring mobile gear fishery of Atlantic herring of the southern Gulf of St. Lawrence.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1978	na	0.100	0.149	0.216	0.257	0.290	0.304	0.343	0.355	0.331	0.404
1979	0.067	0.123	0.180	0.238	0.277	0.301	0.292	0.347	0.368	0.357	0.386
1980	0.033	0.115	0.178	0.210	0.284	0.321	0.343	0.384	0.403	0.404	0.440
1981	0.080	0.111	0.181	0.226	0.256	0.314	0.366	0.234	0.261	na	na
1982	na	0.095	0.168	0.221	0.259	0.279	0.375	0.334	0.355	0.456	0.434
1983	na	0.103	0.170	0.213	0.246	0.283	0.316	0.375	0.349	0.222	0.456
1984	na	0.095	0.146	0.208	0.248	0.279	0.305	0.329	0.373	0.392	0.433
1985	na	0.090	0.190	0.215	0.258	0.281	0.311	0.326	0.382	0.419	na
1986	na	0.116	0.158	0.207	0.252	0.276	0.306	0.328	0.335	0.362	0.404
1987	na	0.111	0.172	0.218	0.250	0.284	0.319	0.341	0.351	0.391	0.393
1988	0.074	0.095	0.157	0.220	0.261	0.307	0.327	0.341	0.342	0.414	0.382
1989	na	0.099	0.159	0.213	0.250	0.279	0.319	0.323	0.327	0.360	0.377
1990	na	0.105	0.171	0.213	0.236	0.289	0.310	0.323	0.329	0.338	0.386
1991	na	na	0.149	0.191	0.221	0.263	0.279	0.307	0.309	0.327	0.380
1992	na	0.072	0.127	0.172	0.211	0.233	0.257	0.281	0.288	0.298	0.335
1993	na	0.076	0.128	0.155	0.195	0.222	0.249	0.272	0.303	0.310	0.347
1994	na	0.086	0.134	0.163	0.178	0.215	0.229	0.266	0.291	0.301	0.339
1995	na	0.084	0.130	0.165	0.179	0.199	0.224	0.241	0.269	0.309	0.339
1996	na	0.090	0.133	0.169	0.195	0.215	0.237	0.257	0.272	0.296	0.334
1997	na	0.082	0.142	0.167	0.193	0.228	0.229	0.250	0.264	0.296	0.336
1998	na	0.076	0.126	0.165	0.186	0.221	0.239	0.232	0.299	0.281	0.356
1999	na	0.072	0.128	0.155	0.189	0.208	0.236	0.233	0.261	0.226	0.287
2000	na	0.077	0.131	0.162	0.184	0.206	0.228	0.247	0.258	0.263	0.292
2001	0.023	0.078	0.129	0.156	0.184	0.199	0.213	0.238	0.246	0.233	0.290
2002	na	0.084	0.149	0.190	0.223	0.247	0.274	0.292	0.328	0.333	0.371
2003	na	0.081	0.138	0.169	0.197	0.219	0.240	0.260	0.276	0.318	0.309
2004	na	0.080	0.131	0.160	0.181	0.204	0.224	0.248	0.265	0.278	0.289
2005	na	0.078	0.125	0.151	0.177	0.202	0.228	0.282	0.284	0.301	0.349
2006	na	0.079	0.132	0.164	0.181	0.206	0.215	0.228	0.264	0.301	0.345
2007	na	0.086	0.127	0.152	0.165	0.184	0.202	0.215	0.226	0.258	0.205
2008	na	0.093	0.133	0.153	0.159	0.179	0.184	0.197	0.210	0.218	na
2009	na	0.092	0.123	0.146	0.166	0.179	0.195	0.220	0.231	na	na
2010	0.044	0.094	0.119	0.136	0.154	0.165	0.175	0.196	0.192	0.205	0.234
2011	na	0.069	0.104	0.123	0.141	0.153	0.168	0.179	0.200	0.186	0.234
2012	na	0.076	0.107	0.125	0.140	0.154	0.152	0.194	0.200	0.194	0.234
2013	0.033	0.077	0.112	0.130	0.146	0.162	0.177	0.189	0.202	0.219	0.232
2014	na	0.065	0.109	0.134	0.149	0.168	0.177	0.190	0.212	0.219	na

Table 4. Fall fishery weights at age (kg) based on sampling of fixed and mobile gear catches of Atlantic herring of the southern Gulf of St. Lawrence.

	Age (years)									
Year	2	3	4	5	6	7	8	9	10	11+
1978	0.099	0.148	0.219	0.256	0.284	0.296	0.341	0.335	0.320	0.393
1979	0.123	0.180	0.239	0.274	0.298	0.307	0.353	0.375	0.367	0.382
1980	0.110	0.150	0.189	0.245	0.255	0.297	0.343	0.392	0.394	0.424
1981	0.115	0.196	0.248	0.303	0.354	0.385	0.402	0.356	0.469	0.452
1982	0.095	0.179	0.258	0.290	0.327	0.375	0.375	0.388	0.397	0.439
1983	0.103	0.173	0.235	0.274	0.308	0.340	0.375	0.365	0.360	0.440
1984	0.095	0.181	0.239	0.274	0.309	0.338	0.385	0.409	0.402	0.486
1985	0.090	0.192	0.233	0.283	0.316	0.349	0.371	0.399	0.429	0.466
1986	0.147	0.174	0.243	0.284	0.316	0.359	0.381	0.384	0.421	0.429
1987	0.112	0.218	0.246	0.280	0.311	0.342	0.365	0.386	0.391	0.426
1988	0.095	0.182	0.256	0.285	0.320	0.343	0.371	0.395	0.403	0.410
1989	0.099	0.173	0.248	0.285	0.317	0.343	0.361	0.375	0.397	0.412
1990	0.112	0.182	0.240	0.276	0.322	0.347	0.366	0.381	0.403	0.430
1991	na	0.151	0.218	0.251	0.289	0.325	0.347	0.361	0.367	0.397
1992	0.072	0.130	0.207	0.246	0.273	0.298	0.334	0.342	0.349	0.377
1993	0.076	0.129	0.188	0.235	0.257	0.274	0.308	0.334	0.332	0.370
1994	0.086	0.134	0.185	0.223	0.250	0.277	0.309	0.333	0.351	0.379
1995	0.072	0.119	0.185	0.213	0.236	0.271	0.288	0.323	0.353	0.378
1996	0.089	0.133	0.198	0.231	0.248	0.265	0.300	0.320	0.352	0.390
1997	0.082	0.148	0.195	0.229	0.254	0.264	0.297	0.317	0.336	0.387
1998	0.076	0.127	0.206	0.229	0.256	0.283	0.286	0.323	0.333	0.374
1999	0.072	0.129	0.197	0.231	0.245	0.269	0.289	0.298	0.342	0.355
2000	0.077	0.133	0.199	0.228	0.254	0.270	0.297	0.312	0.320	0.357
2001	0.078	0.130	0.199	0.227	0.246	0.267	0.281	0.293	0.310	0.311
2002	0.084	0.152	0.212	0.236	0.254	0.277	0.291	0.316	0.321	0.343
2003	0.081	0.139	0.192	0.227	0.247	0.263	0.284	0.300	0.327	0.337
2004	0.080	0.131	0.189	0.216	0.238	0.255	0.279	0.294	0.305	0.325
2005	0.078	0.125	0.165	0.217	0.235	0.249	0.273	0.284	0.295	0.327
2006	0.079	0.133	0.189	0.214	0.237	0.250	0.261	0.286	0.293	0.312
2007	0.086	0.128	0.177	0.200	0.222	0.238	0.246	0.260	0.268	0.289
2008	0.093	0.132	0.175	0.207	0.222	0.236	0.246	0.251	0.265	0.284
2009	0.092	0.128	0.181	0.200	0.230	0.246	0.260	0.269	0.269	0.269
2010	0.094	0.118	0.154	0.195	0.210	0.233	0.251	0.261	0.278	0.290
2011	0.069	0.104	0.152	0.181	0.210	0.220	0.245	0.261	0.262	0.274
2012	0.076	0.107	0.140	0.180	0.198	0.213	0.221	0.244	0.257	0.274
2013	0.078	0.115	0.141	0.182	0.198	0.209	0.225	0.230	0.256	0.266
2014	0.065	0.109	0.141	0.179	0.208	0.218	0.225	0.240	0.238	0.297

Table 5. Estimated beginning of year weights at age (kg) of fall spawning herring of the southern Gulf of St. Lawrence.

	Age (years)									
Year	2	3	4	5	6	7	8	9	10	11+
1978	0.074	0.116	0.196	0.238	0.273	0.271	0.325	0.320	0.293	0.389
1979	0.112	0.134	0.188	0.245	0.277	0.295	0.323	0.357	0.351	0.350
1980	0.083	0.136	0.185	0.242	0.265	0.297	0.324	0.372	0.384	0.395
1981	0.092	0.147	0.193	0.240	0.295	0.314	0.345	0.349	0.429	0.422
1982	0.070	0.143	0.225	0.268	0.315	0.365	0.380	0.395	0.376	0.454
1983	0.077	0.128	0.205	0.266	0.299	0.333	0.375	0.370	0.374	0.418
1984	0.067	0.136	0.203	0.254	0.291	0.323	0.362	0.391	0.383	0.418
1985	0.064	0.135	0.205	0.260	0.294	0.328	0.354	0.392	0.419	0.433
1986	0.120	0.125	0.216	0.257	0.299	0.337	0.365	0.378	0.410	0.429
1987	0.088	0.179	0.207	0.261	0.297	0.328	0.362	0.384	0.388	0.424
1988	0.070	0.143	0.236	0.265	0.300	0.326	0.356	0.379	0.395	0.401
1989	0.073	0.128	0.213	0.270	0.301	0.331	0.352	0.373	0.396	0.408
1990	0.097	0.134	0.204	0.262	0.303	0.331	0.354	0.371	0.389	0.413
1991	0.073	0.130	0.199	0.246	0.283	0.324	0.347	0.364	0.374	0.400
1992	0.053	0.113	0.176	0.232	0.262	0.294	0.330	0.344	0.355	0.372
1993	0.057	0.096	0.156	0.220	0.251	0.274	0.303	0.334	0.337	0.359
1994	0.074	0.101	0.154	0.204	0.242	0.267	0.291	0.320	0.342	0.355
1995	0.053	0.101	0.158	0.199	0.229	0.260	0.283	0.316	0.342	0.365
1996	0.070	0.098	0.153	0.207	0.230	0.250	0.285	0.303	0.337	0.371
1997	0.065	0.115	0.161	0.213	0.242	0.256	0.281	0.308	0.328	0.369
1998	0.058	0.102	0.175	0.211	0.242	0.268	0.275	0.310	0.325	0.354
1999	0.053	0.099	0.158	0.218	0.237	0.263	0.286	0.292	0.332	0.344
2000	0.059	0.097	0.160	0.212	0.242	0.258	0.283	0.301	0.309	0.350
2001	0.056	0.100	0.162	0.212	0.237	0.260	0.276	0.295	0.311	0.315
2002	0.065	0.109	0.166	0.217	0.240	0.261	0.279	0.298	0.307	0.326
2003	0.064	0.108	0.171	0.219	0.241	0.258	0.280	0.295	0.322	0.329
2004	0.064	0.103	0.162	0.204	0.232	0.251	0.271	0.289	0.303	0.326
2005	0.060	0.100	0.147	0.203	0.225	0.244	0.264	0.281	0.295	0.316
2006	0.062	0.102	0.154	0.188	0.227	0.242	0.255	0.280	0.289	0.304
2007	0.084	0.100	0.153	0.195	0.218	0.237	0.248	0.260	0.277	0.291
2008	0.067	0.088	0.148	0.170	0.185	0.198	0.213	0.235	0.262	0.276
2009	0.081	0.130	0.200	0.207	0.252	0.267	0.280	0.283	0.269	0.267
2010	0.077	0.104	0.140	0.188	0.205	0.232	0.248	0.260	0.274	0.279
2011	0.075	0.099	0.134	0.167	0.203	0.215	0.239	0.256	0.262	0.276
2012	0.078	0.086	0.121	0.165	0.189	0.212	0.221	0.244	0.259	0.268
2013	0.077	0.093	0.123	0.160	0.189	0.204	0.219	0.225	0.250	0.261
2014	0.076	0.092	0.127	0.159	0.195	0.208	0.217	0.232	0.234	0.276

Table 6a. Fall spawner catch-at-age (thousand) for fixed gear in the 4T herring fishery for the North region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	0	216	3414	2450	510	432	2709	50	81	1189	11049
1979	0	0	168	3271	1465	1260	256	644	531	252	267	8113
1980	0	26	3056	1471	1648	233	1154	129	110	147	0	7974
1981	0	23	3963	12839	2839	593	240	278	53	99	60	20988
1982	0	0	1726	5625	11797	1746	331	202	64	40	62	21593
1983	0	0	98	9238	3748	9002	1018	413	96	16	102	23732
1984	0	0	453	7434	6808	3462	3133	556	113	108	71	22140
1985	0	0	99	2878	13139	8176	4901	4915	1832	372	6	36317
1986	0	0	617	9919	9734	21934	15361	7286	3326	447	770	69394
1987	0	16	7260	24247	14636	13277	19804	9068	5494	2412	759	96973
1988	0	0	152	14470	24858	9543	8464	7752	4121	1998	1953	73312
1989	0	0	283	12133	19801	21160	10289	4716	5928	2655	2119	79083
1990	0	14	2351	13755	12557	19491	20685	7816	5478	5759	4141	92048
1991	0	0	131	28732	7306	5390	7996	7653	2463	1539	2511	63721
1992	0	0	11	6153	37342	10677	6225	6775	5960	2872	5423	81438
1993	0	0	82	2051	21080	24447	3430	1918	1975	559	712	56253
1994	0	0	0	6553	10534	31558	47627	9076	7049	3229	5405	121030
1995	0	0	23	3298	23949	11095	26764	28406	4969	3188	3483	105176
1996	0	0	0	12767	15443	20775	4565	8681	9465	1341	1561	74599
1997	0	0	367	8897	30662	9453	8423	1621	2817	2524	732	65496
1998	0	0	37	8752	23986	22898	5734	5461	787	1272	2305	71232
1999	0	0	175	19795	23825	29632	10527	2083	1327	362	517	88244
2000	0	0	266	17183	56056	14915	6279	3445	668	493	224	99529
2001	0	0	516	22863	28903	29781	4552	2051	561	175	228	89629
2002	0	1	212	21279	23278	16324	8777	2292	683	471	187	73503
2003	0	0	235	11578	24362	16356	11533	13769	3446	1512	948	83741
2004	0	0	1	23785	17748	8619	5219	4049	2776	638	433	63267
2005	0	0	1	5034	56213	22399	8627	4759	2861	2025	184	102102
2006	0	0	5	6092	37842	36714	5458	1549	2922	1127	602	92312
2007	0	0	32	5160	15268	34715	23878	5096	951	887	561	86549
2008	0	0	403	18423	11717	18718	15180	14670	1778	598	865	82352
2009	0	0	532	22606	38575	10619	10493	6117	1701	302	253	91199
2010	0	0	0	3120	26685	23029	7969	5320	4186	1708	199	72217
2011	0	0	0	1657	6387	26763	24243	2750	3140	2850	773	68564
2012	0	0	8	156	8609	17648	26305	11769	2342	2749	954	70540
2013	0	0	0	1053	9008	29030	20823	10696	2295	183	103	73191
2014	0	0	0	91	4453	9817	24451	11216	7583	100	60	57771

Table 6b. Fall spawner catch-at-age (thousand) for fixed gear in the 4T herring fishery for the Middle region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	0	38	601	749	220	442	2005	9	59	1139	5262
1979	0	0	144	3673	2048	831	205	100	209	18	161	7389
1980	0	0	424	964	2283	579	271	225	282	107	96	5232
1981	0	0	974	6224	1910	1150	460	629	31	83	238	11699
1982	0	0	29	1653	1559	210	139	116	0	0	31	3737
1983	0	0	255	3998	1482	1578	351	130	0	0	0	7794
1984	0	0	41	1908	2723	937	1001	315	77	11	6	7019
1985	0	0	11	235	1370	1010	562	536	200	41	1	3964
1986	0	0	47	1600	1328	2455	1120	435	200	27	46	7257
1987	0	0	298	934	1761	1532	3059	289	267	298	19	8457
1988	0	0	817	3091	2817	2473	1135	1189	886	15	0	12424
1989	0	0	16	772	1431	1274	694	428	378	171	139	5303
1990	0	0	219	1923	1390	1508	2655	548	382	298	64	8987
1991	0	0	17	5973	1617	1332	1749	2066	1271	585	1335	15945
1992	0	0	12	3880	9415	1284	534	304	220	106	249	16004
1993	0	0		350	6612	8298	1417	597	415	470	716	18875
1994	0	0		850	1373	6909	9293	1134	359	439	741	21099
1995	0	0		214	10009	3408	12249	10646	1363	243	4272	42403
1996	0	0		3414	2107	12096	1046	3144	3605	833	869	27113
1997	0	0	285	4835	10979	1980	4125	782	938	1026	639	25588
1998	0	0	23	5113	4301	8730	1761	3286	596	1293	2229	27331
1999	0	0		9710	12903	5104	3222	1303	2854	278	1330	36703
2000	0	0	13	11054	21136	7789	2516	1394	414	369	165	44850
2001	0	0	383	5519	13582	9633	2919	630	208	0	293	33167
2002	0	0	275	9081	8110	7172	6937	1245	172	146	217	33356
2003	0	0	123	5648	11842	5541	3737	3739	839	110	156	31735
2004	0	0	15	5579	10122	7144	5096	4523	2652	920	175	36227
2005	0	0		2355	14518	11757	3536	3046	2099	895	66	38273
2006	0	0		1697	7740	13789	5094	2598	1949	1544	523	34935
2007	0	0	193	1197	3429	9509	9811	3736	1509	733	454	30572
2008	0	0	1426	12175	2575	4491	5326	8515	1536	1451	332	37826
2009	0	0	101	8185	14543	3368	7438	3578	1245	530	245	39232
2010	0	0	8	1529	11467	17000	4954	4333	2473	1154	644	43562
2011	0	0	0	405	2089	12157	15610	2973	2237	2101	631	38202
2012	0	0	7	147	1935	8679	11646	8142	925	526	443	32450
2013	0	0	7	590	1125	7042	10527	6451	2488	201	43	28474
2014	0	0	0	0	2490	2502	6281	8826	1583	873	0	22556

Table 6c. Fall spawner catch-at-age (thousand) for fixed gear in the 4T herring fishery for the South region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	41	1988	1390	632	154	75	119	22	0	13	4434
1979	910	16	267	4634	2198	773	263	292	175	52	205	9786
1980	0	38	4404	1939	2352	294	923	129	164	154	77	10473
1981	0	42	1158	5336	2185	1049	531	310	88	99	24	10823
1982	0	0	353	7029	3634	3226	2345	819	332	81	37	17856
1983	0	0	467	7485	5047	3237	1011	1266	477	47	161	19198
1984	0	0	397	15010	5562	4586	2288	703	381	110	23	29060
1985	0	0	89	3442	15465	6385	3221	2234	509	333	29	31707
1986	0	383	871	20436	5745	12065	3350	1635	487	106	164	45244
1987	0	0	1083	11141	12821	6139	14100	6213	4292	1851	1323	58963
1988	0	0	377	4361	16703	9665	4750	6641	3036	985	665	47183
1989	0	0	33	1355	2076	8332	4204	1803	2446	622	300	21171
1990	0	0	875	6772	6732	7712	36015	9853	4322	4591	2472	79345
1991	0	0	11	4956	1670	1339	1201	3899	1365	840	1190	16472
1992	0	0	0	1335	7461	1081	631	1510	3338	1241	1316	17912
1993	0	0	0	302	3227	3902	982	405	586	485	1123	11013
1994	0	0	0	1463	310	10000	13800	1873	2460	5256	8730	43892
1995	0	0	1	341	7908	2733	12171	10381	2759	3036	7345	46675
1996	0	0	4	3477	2082	13644	4899	11411	10891	2781	8448	57637
1997	0	0	454	3780	22567	2027	8585	1488	3105	2920	2597	47521
1998	0	0	0	9390	4415	15711	3964	8891	1751	3429	4223	51773
1999	0	0	89	8880	32161	4365	9706	1899	3102	1152	1593	62949
2000	0	0	77	8101	31645	18887	3076	3685	715	1148	717	68050
2001	0	0	56	1816	22486	21033	13536	1991	1593	433	824	63767
2002	0	0	0	17708	7514	16987	14117	4249	1072	926	547	63120
2003	0	0	61	5076	41894	6513	13669	8690	1700	262	381	78246
2004	0	0	0	4823	11135	24502	4842	4452	2175	600	312	52840
2005	0	0	3	424	12345	20406	31839	6051	6169	1732	385	79354
2006	0	0	51	2825	7738	20291	20875	15511	5119	2721	760	75890
2007	0	0	492	206	9238	13512	24751	15374	4948	2939	938	72397
2008	0	0	292	4858	1774	6585	12063	15009	6873	3646	2818	53919
2009	0	0	411	2398	20654	10345	20617	6815	3615	5240	2610	72705
2010	0	0	0	2080	8754	32103	8352	10398	6809	3819	2439	74754
2011	0	0	1	312	7530	7478	25275	8102	4030	2350	4185	59263
2012	0	0	0	24	1199	12938	14639	15613	1662	476	1603	48156
2013	0	0	15	341	1025	9166	19571	7271	3448	110	108	41054
2014	0	0	0	173	2842	2276	8970	15940	3389	1657	36	35281

Table 7a. Fall spawner catch-at-age (thousand) for mobile gear in the 4T herring fishery of the North region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	79	4054	12822	17080	2899	2891	10421	1050	511	11781	63149
1979	155	5920	8880	6475	4166	3064	1118	687	1783	263	2633	32916
1980	139	2317	17087	4629	1872	678	734	373	452	307	492	28976
1981	1	33	292	344	31	9	13	1	5	0	0	728
1982	0	1014	8857	3562	6916	830	131	153	103	25	260	21854
1983	0	9	242	291	112	175	31	7	10	1	4	882
1984	0	378	1020	4581	4736	2610	1705	367	84	10	37	15528
1985	0	331	1904	2489	7414	6556	2955	2205	1837	574	0	26263
1986	0	272	2098	2483	3109	5959	3521	1564	1614	208	218	21336
1987	0	1622	3350	2275	1030	1329	3638	3869	865	864	371	19214
1988	97	3900	2467	2731	3207	1539	3197	2786	1060	1384	1608	23976
1989	0	828	1073	2202	4390	4541	1899	2252	2706	1557	1182	22630
1990	0	71	4463	3357	3653	2019	1981	1549	2084	988	296	20461
1991	0	0	5138	18139	4009	1188	1942	1452	382	712	2282	35246
1992	0	44	586	5067	12734	2263	1385	957	1158	935	4768	30479
1993	0	311	4383	2693	4587	7513	2282	1874	1767	2377	3285	31072
1994	0	0	275	6305	2091	4865	6027	921	415	403	697	22542
1995	0	0	1861	3547	19016	6060	8390	8584	1916	596	2084	52351
1996	0	359	2684	10407	2556	8340	2346	1813	1446	438	403	30510
1997	0	362	4079	5423	6371	1235	2540	477	923	557	419	21800
1998	0	51	1489	2898	2848	1690	469	1778	108	455	144	11879
1999	0	690	7217	10835	5770	2761	1239	767	490	183	112	30065
2000	0	793	4875	8784	10216	2650	1369	582	223	272	136	29899
2001	144	1194	6603	4579	5105	4098	705	490	228	0	21	23166
2002	0	76	1363	7505	6378	4178	4009	975	321	346	217	25367
2003	0	0	4531	9687	5600	3695	3219	3961	960	549	318	32520
2004	0	71	2533	8511	3204	1537	741	344	333	40	0	17314
2005	0	802	3145	9147	7649	1800	240	100	159	42	38	23122
2006	0	800	1966	3218	7747	5366	1417	493	315	239	54	21616
2007	0	1491	14991	4688	2787	2987	1571	390	81	3	12	29000
2008	0	1385	8080	5566	1678	834	607	771	3	24	0	18948
2009	0	179	4648	5917	2313	295	211	51	5	0	0	13618
2010	11	6	1811	6112	10088	6857	1258	684	203	90	0	27119
2011	0	1177	749	2101	2304	2477	1015	368	8	59	6	10263
2012	0	42	379	314	931	641	410	9	0	9	0	2734
2013	17	527	447	2904	1833	2390	1318	499	241	18	5	10200
2014	0	36	1780	596	2685	1301	1582	942	455	94	0	9470

Table 7b. Fall spawner catch-at-age (thousand) for mobile gear in the 4T herring fishery of the Middle region of the southern Gulf of St. Lawrence.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	20	948	4808	1863	538	633	1578	197	59	1753	12277
1979	0	0	0	0	0	3097	745	2065	1754	1313	7202	17887
1980	8	135	1022	284	137	53	48	24	29	20	30	1784
1981	0	5	44	52	5	1	2	0	1	0	0	110
1982	0	4	31	12	24	3	0	1	0	0	1	77
1983	0	207	5327	6407	2466	3865	672	156	209	28	85	19422
1984	0	20	54	242	251	138	90	19	4	1	2	820
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	2	3	2	1	1	3	4	1	1	0	18
1988	0	0	0	0	0	0	0	0	0	0	0	1
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	3	24	369	127	122	102	121	70	23	30	956
1997	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	61	283	567	1695	152	140	141	360	427	3848
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	320	464	288	464	190	64	0	0	3	1795
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	154	1321	8673	7234	3128	988	583	515	229	116	22941
2006	0	1	28	192	574	85	30	15	0	0	0	926
2007	0	0	176	238	37	322	118	87	19	31	8	1036
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0

Table 7c. Fall spawner catch-at-age (thousand) for mobile gear in the 4T herring fishery of the South region of the southern Gulf of St. Lawrence.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	0	1252	16405	5700	2552	899	1528	3024	597	698	4256	37472
1979	1	31	84	597	780	1071	215	489	313	83	2055	6239
1980	3	493	23229	10890	19861	9562	4078	1396	2103	1419	1328	74471
1981	17	1081	9675	11391	1040	287	432	30	181	0	0	24134
1982	0	0	0	11	22	8	4	2	1	0	2	47
1983	0	5	139	167	64	101	18	4	5	1	2	506
1984	0	0	1	2	1	1	1	0	0	0	0	5
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	74	426	135	6	7	5	1	0	0	0	366
1987	0	9	19	13	6	8	21	22	5	5	2	110
1988	1	50	32	35	42	20	41	36	14	18	21	310
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	76	341	619	738	657	485	536	395	100	3367
1993	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	13	2188	1578	5388	7248	775	1388	962	2032	21042
1995	0	22	505	251	1389	367	1402	1762	114	347	402	6262
1996	0	28	6	2463	3060	2247	1637	1285	578	369	649	12636
1997	0	66	799	889	3491	1199	2075	422	457	231	497	10712
1998	0	0	3	16	113	349	116	490	91	273	697	2177
1999	0	23	846	2005	3480	2109	4730	2132	1738	460	1233	18756
2000	0	236	1926	3738	1875	1020	371	459	83	47	118	9875
2001	2	831	6223	2837	4609	4693	1956	1337	836	250	310	23885
2002	0	954	2799	6060	4530	4663	3411	870	232	455	174	24148
2003	0	201	4034	5966	6382	3697	4609	3633	1543	303	357	30726
2004	0	448	2059	6792	3471	2984	2191	1801	1445	467	333	21992
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	240	360	260	420	381	129	10	15	3	0	1817
2007	0	0	70	95	15	128	47	34	8	12	3	411
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	64	928	516	342	38	21	5	0	1	1914
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	40	211	413	149	333	56	5	7	1214
2013	0	18	0	1502	2107	3489	5125	2162	1870	202	98	16575
2014	0	0	0	496	2895	1691	2199	1972	990	263	0	10505

Table 8. Percent of fishing days with no gillnet catch derived from the telephone survey for main fishing areas (Areas 2, 3, 4, 6, 7, 8; see Fig. 1 for area locations) in the fall Atlantic herring fishery of the southern Gulf of St. Lawrence.

Year	Percent
2006	16.7
2007	28.8
2008	28.8
2009	17.5
2010	19.9
2011	27.3
2012	24.2
2013	22.8
2014	31.5

Table 9. Results of the multiplicative general linear model applied to the fishery catch-per-unit-effort data of Atlantic herring fall spawners for the entire stock area (NAFO 4T) and for each region. Note that all models included factors for year and week while only the whole stock area (NAFO 4T) model also included a factor for region.

Area	R^2	F_{year}	P_{year}	F_{week}	P_{week}	F_{region}	P_{region}
NAFO 4T	0.43	18.85	<0.0001	94.89	<0.0001	121.82	<0.0001
North region	0.57	2.92	<0.0001	17.21	<0.0001	NA	NA
Middle region	0.67	2.04	<0.0001	12.70	<0.0001	NA	NA
South region	0.54	3.53	<0.0001	15.13	<0.0001	NA	NA

Table 10. Fall spawner gillnet catch-per-unit-effort values (number per net-haul) for Atlantic herring for NAFO Div. 4T.

	Age (years)							
Year	4	5	6	7	8	9	10	11+
1986	142.9	75.2	163.0	88.7	41.8	18.0	2.6	4.4
1987	94.1	75.7	54.3	95.8	40.3	26.0	11.8	5.4
1988	58.4	118.2	57.7	38.2	41.5	21.4	8.0	7.0
1989	73.3	119.8	158.1	78.0	35.7	45.0	17.7	13.1
1990	39.3	36.2	50.3	104.0	31.9	17.8	18.7	11.7
1991	211.0	56.4	42.9	58.2	72.4	27.1	15.8	26.8
1992	47.7	227.4	54.7	31.0	36.0	39.9	17.7	29.3
1993	14.9	170.4	202.0	32.1	16.1	16.4	8.3	14.1
1994	16.0	22.0	87.4	127.5	21.8	17.8	16.1	26.8
1995	5.0	54.7	22.5	66.9	64.6	11.9	8.4	19.7
1996	36.4	36.4	86.2	19.5	43.1	44.4	9.2	20.2
1997	62.7	229.9	48.2	75.7	13.9	24.6	23.2	14.2
1998	55.2	77.7	112.4	27.2	41.9	7.4	14.2	20.8
1999	80.0	143.5	81.5	48.9	11.0	15.2	3.7	7.2
2000	100.5	301.0	115.0	32.8	23.6	5.0	5.6	3.1
2001	80.4	172.9	160.9	55.9	12.4	6.3	1.6	3.6
2002	153.3	124.1	129.1	95.2	24.8	6.1	4.9	3.0
2003	54.2	189.7	69.0	70.3	63.6	14.5	4.6	3.6
2004	96.3	109.9	113.5	42.7	36.7	21.4	6.1	2.6
2005	24.1	256.3	168.3	135.7	42.7	34.3	14.3	2.0
2006	40.2	201.7	267.8	118.9	74.4	37.8	20.4	7.1
2007	26.5	112.7	232.9	235.8	97.7	29.9	18.4	7.9
2008	110.8	50.2	93.1	101.8	119.4	31.8	17.8	12.5
2009	95.6	212.4	70.1	111.0	47.5	18.9	17.5	9.0
2010	18.4	128.3	197.3	58.2	54.8	36.8	18.3	9.0
2011	6.1	41.0	118.9	166.9	35.4	24.1	18.7	14.3
2012	0.8	28.8	96.4	129.1	87.2	12.1	9.2	7.4
2013	7.5	42.4	172.1	193.7	92.9	31.3	1.9	1.0
2014	1.5	55.7	83.1	226.1	205.0	71.5	15.0	0.5

Table 11a. Fall spawner gillnet catch-per-unit-effort values (number per net-haul) by age for Atlantic herring for the North region of the southern Gulf of St. Lawrence.

	Age (years)						
Year	4	5	6	7	8	9	10
1986	106.4	104.4	235.3	164.8	78.2	35.7	4.8
1987	199.9	120.6	109.4	163.2	74.7	45.3	19.9
1988	118.5	203.6	78.2	69.3	63.5	33.8	16.4
1989	194.5	317.5	339.3	165.0	75.6	95.0	42.6
1990	74.9	68.4	106.2	112.7	42.6	29.8	31.4
1991	527.5	134.1	99.0	146.8	140.5	45.2	28.3
1992	81.2	492.5	140.8	82.1	89.3	78.6	37.9
1993	33.1	340.0	394.3	55.3	30.9	31.9	9.0
1994	44.2	71.0	212.8	321.2	61.2	47.5	21.8
1995	19.3	140.3	65.0	156.8	166.4	29.1	18.7
1996	90.6	109.6	147.4	32.4	61.6	67.2	9.5
1997	98.5	339.5	104.7	93.3	18.0	31.2	27.9
1998	61.9	169.5	161.9	40.5	38.6	5.6	9.0
1999	134.1	161.4	200.7	71.3	14.1	9.0	2.5
2000	166.6	543.5	144.6	60.9	33.4	6.5	4.8
2001	157.5	199.1	205.1	31.4	14.1	3.9	1.2
2002	207.7	227.2	159.4	85.7	22.4	6.7	4.6
2003	88.1	185.3	124.4	87.7	104.7	26.2	11.5
2004	226.5	169.0	82.1	49.7	38.6	26.4	6.1
2005	51.3	572.8	228.3	87.9	48.5	29.2	20.6
2006	17.3	107.3	104.1	15.5	4.4	8.3	3.2
2007	37.5	111.0	252.5	173.7	37.1	6.9	6.5
2008	70.9	45.1	72.1	58.4	56.5	6.8	2.3
2009	127.1	216.8	59.7	59.0	34.4	9.6	1.7
2010	18.9	161.7	139.5	48.3	32.2	25.4	10.3
2011	8.6	33.1	138.6	125.5	14.2	16.3	14.8
2012	1.2	64.4	132.0	196.8	88.0	17.5	20.6
2013	9.7	82.8	266.8	191.4	98.3	21.1	1.7
2014	1.8	86.8	191.5	476.8	218.7	147.9	1.9

Table 11b. Fall spawner gillnet catch-per-unit-effort values (number per net-haul) by age for Atlantic herring for the Middle region of the southern Gulf of St. Lawrence.

	Age (years)						
Year	4	5	6	7	8	9	10
1986	134.9	112.0	207.0	94.4	36.6	16.9	2.3
1987	86.0	162.2	141.1	281.9	26.6	24.6	27.5
1988	75.0	68.4	60.0	27.5	28.8	21.5	0.4
1989	25.5	47.3	42.2	23.0	14.1	12.5	5.7
1990	51.4	37.1	40.3	70.9	14.6	10.2	8.0
1991	167.4	45.3	37.3	49.0	57.9	35.6	16.4
1992	112.4	272.7	37.2	15.5	8.8	6.4	3.1
1993	10.3	195.2	245.0	41.8	17.6	12.3	13.9
1994	15.3	24.8	124.6	167.6	20.5	6.5	7.9
1995	2.9	137.0	46.6	167.7	145.7	18.7	3.3
1996	66.2	40.8	234.5	20.3	60.9	69.9	16.1
1997	134.8	306.0	55.2	115.0	21.8	26.1	28.6
1998	58.3	49.0	99.5	20.1	37.5	6.8	14.7
1999	128.1	170.3	67.3	42.5	17.2	37.7	3.7
2000	215.1	411.2	151.5	49.0	27.1	8.1	7.2
2001	113.7	279.9	198.5	60.1	13.0	4.3	0.0
2002	155.5	138.9	122.8	118.8	21.3	2.9	2.5
2003	91.3	191.5	89.6	60.4	60.5	13.6	1.8
2004	136.1	246.9	174.3	124.3	110.3	64.7	22.4
2005	58.6	361.2	292.5	88.0	75.8	52.2	22.3
2006	51.5	234.9	418.5	154.6	78.8	59.2	46.9
2007	55.5	158.9	440.7	454.7	173.1	69.9	34.0
2008	346.7	73.3	127.9	151.6	242.4	43.7	41.3
2009	166.9	296.5	68.7	151.7	73.0	25.4	10.8
2010	13.9	104.2	154.5	45.0	39.4	22.5	10.5
2011	4.8	24.5	142.7	183.2	34.9	26.3	24.7
2012	2.5	33.4	149.8	201.0	140.5	16.0	9.1
2013	18.2	34.7	217.1	324.6	198.9	76.7	6.2
2014	0.0	37.2	37.4	93.8	131.8	23.6	13.0

Table 11c. Fall spawner gillnet catch-per-unit-effort values (number per net-haul) by age for Atlantic herring for the South region of the southern Gulf of St. Lawrence.

	Age (years)						
Year	4	5	6	7	8	9	10
1986	445.4	125.2	263.0	73.0	35.6	10.6	2.3
1987	134.7	155.0	74.2	170.4	75.1	51.9	22.4
1988	60.7	232.6	134.6	66.1	92.5	42.3	13.7
1989	107.6	164.9	661.8	333.9	143.2	194.3	49.4
1990	109.5	108.9	124.7	582.6	159.4	69.9	74.3
1991	351.1	118.3	94.8	85.1	276.2	96.7	59.5
1992	99.5	556.0	80.6	47.0	112.6	248.8	92.5
1993	30.3	323.2	390.8	98.4	40.6	58.7	48.5
1994	35.3	7.5	241.4	333.2	45.2	59.4	126.9
1995	4.2	96.6	33.4	148.7	126.8	33.7	37.1
1996	44.2	26.5	173.6	62.3	145.2	138.6	35.4
1997	123.7	738.7	66.3	281.0	48.7	101.6	95.6
1998	121.3	57.0	202.9	51.2	114.8	22.6	44.3
1999	148.9	539.4	73.2	162.8	31.9	52.0	19.3
2000	119.0	465.0	277.5	45.2	54.1	10.5	16.9
2001	39.4	487.9	456.4	293.7	43.2	34.6	9.4
2002	379.1	160.9	363.6	302.2	91.0	23.0	19.8
2003	100.4	828.6	128.8	270.4	171.9	33.6	5.2
2004	112.8	260.5	573.3	113.3	104.2	50.9	14.0
2005	9.9	288.7	477.2	744.5	141.5	144.2	40.5
2006	76.7	210.1	550.9	566.7	421.1	139.0	73.9
2007	8.0	357.6	523.1	958.2	595.2	191.6	113.8
2008	129.3	47.2	175.3	321.1	399.6	183.0	97.1
2009	54.1	466.0	233.4	465.1	153.7	81.6	118.2
2010	50.2	211.3	774.8	201.6	251.0	164.3	92.2
2011	7.5	180.8	179.5	606.9	194.5	96.8	56.4
2012	0.3	12.9	138.7	157.0	167.4	17.8	5.1
2013	9.0	27.1	242.2	517.3	192.2	91.1	2.9
2014	5.4	89.7	71.8	283.1	503.0	107.0	52.3

Table 12. Intra-cohort adjoining-year correlations (Pearson r) for the CPUE indices, as a measure of internal consistency, for the fall spawner component of Atlantic herring from the southern Gulf of St. Lawrence. Correlations were calculated by region and for the whole area.

Ages	North	Middle	South	NAFO 4T
4-5	0.63	0.61	0.50	0.55
5-6	0.32	0.60	0.55	0.68
6-7	0.46	0.65	0.77	0.73
7-8	0.69	0.74	0.78	0.87
8-9	0.59	0.49	0.57	0.58
9-10	0.57	0.60	0.60	0.75

Table 13. Abundance indices derived from the experimental net catches by age, region, and year for the fall spawner component of Atlantic herring from the southern Gulf of St. Lawrence.

		Age (years)								
Region	Year	2	3	4	5	6	7	8	9	10
North	2002	0.2	5.7	33.6	31	15.3	10.4	1.5	0.5	0.1
	2003	0.1	6.2	11	6.2	4.7	3.6	2.9	0.7	0.6
	2004	0.1	1.5	18.5	6.7	2.1	0.9	1	0.7	0.2
	2005	0	0	9.3	18.3	4.8	2	1.2	0.7	0.2
	2006	0	1.1	15.2	36.7	25.9	4.4	0.9	1.4	0.6
	2007	na	na	na	na	na	na	na	na	na
	2008	0.6	16	107.2	21.5	11.7	15.8	12.3	2	1.2
	2009	0.8	19.1	80.7	61	11.9	10.8	7.3	2.7	0.5
	2010	0.2	9.5	38.1	71.3	33.3	3.7	3.5	2.1	0.8
	2011	0	0	14.1	30.4	34.7	19.4	4.3	2.7	1.7
	2012	na	na	na	na	na	na	na	na	na
	2013	0	0.9	32.9	32.7	68.8	50.6	24.8	6.1	1.1
Middle	2002	na	na	na	na	na	na	na	na	na
	2003	1	25.9	72	54.7	21.4	23.2	15.5	3	1
	2004	0	11.2	69	46.3	17.1	7.3	6.7	3.5	1
	2005	0.5	10.2	49.7	70.3	35.9	12.4	7.5	6.1	2.1
	2006	0.1	4.2	20.9	40.7	54.1	23.5	10	6.3	5.1
	2007	0.2	11	8.7	14.5	21.6	22.5	8.8	2.9	2.1
	2008	1	15.4	100.2	15.4	13.2	13.1	12.9	3.3	1.8
	2009	0.4	45.3	159.5	146.1	25.5	29.1	16.6	6	2.1
	2010	0	0.1	1.5	4	5.8	1.2	1.6	1.9	0.9
	2011	0	0.9	18.4	25.6	46	43.2	9.6	7.2	5.7
	2012	0.5	11	7.6	25.5	32.9	39.5	25.2	2.2	1.1
	2013	0.5	5.3	81.9	19	59	52.5	32.7	11.2	0.6
South	2002	0	12	67.2	10.3	12.4	8.9	3.2	0.5	0.2
	2003	1.1	23	50	120.1	20.2	28.9	20.2	6	1
	2004	0.3	13.6	48.7	33.8	46.2	8.9	9.2	4	1.2
	2005	0.3	12.8	16.4	27.5	25.9	34	6.3	6.7	2
	2006	0	2.8	54.7	34.5	68.7	77.8	45	13.4	7.3
	2007	2.7	100.2	15.1	32.1	25.3	35.9	29.3	11.1	3.1
	2008	0.3	14.7	81.1	6.8	17.3	14.8	16.3	9.7	4.7
	2009	0.8	19.9	33.5	77.5	11.5	17.8	7.5	4.9	2.7
	2010	0.4	0.7	25.4	8.9	17.6	1.9	3.3	1.7	1.4
	2011	0	0.9	23.6	48.4	22.1	34.9	3.3	3.9	1.9
	2012	0.6	6	2.7	8	14.3	6.1	6.8	0.9	0.3
	2013	0	0.3	10.9	7.1	26.3	31.9	11.8	4.3	0.2

Table 14. Intra-cohort adjoining-year correlations (Pearson r) for the experimental net indices, as a measure of internal consistency, for Atlantic herring of the southern Gulf of St. Lawrence. Correlations were calculated by region and for the whole area.

Ages	North	Middle	South	NAFO 4T
2-3	0.78	0.55	-0.22	-0.18
3-4	0.73	0.59	0.78	0.80
4-5	0.80	0.87	0.73	0.80
5-6	0.82	0.11	0.27	0.00
6-7	0.88	0.10	0.28	0.33
7-8	0.82	0.76	0.53	0.60
8-9	0.73	0.43	0.50	0.63
9-10	0.57	-0.02	0.55	0.58

Table 15. Experimental net abundance indices at age for fall spawning herring of the southern Gulf of St. Lawrence, calculated as an average of region specific values weighted by regional catch at age.

	Age (years)								
Year	2	3	4	5	6	7	8	9	10
2002	0.01	9.73	48.8	25.02	13.81	9.53	2.54	0.5	0.16
2003	1.1	14.13	31.42	73.62	11.7	18.17	10.6	2.95	0.7
2004	0.27	6.94	31.28	24.14	31.56	5.81	6.08	2.77	0.88
2005	0.08	3.03	26.79	31.01	19.82	25.57	4.9	5.03	1.27
2006	0	1.43	24.48	36.95	42.55	54.08	36	8.29	5.07
2007	1.4	64.85	9.81	27.3	23.75	32.07	25.23	9.17	2.89
2008	0.6	15.88	102.03	19.15	13.12	15	13.97	7.39	3.58
2009	0.8	19.62	94.3	81.75	13.59	18.04	9.39	4.54	2.54
2010	0.2	9.16	31.26	47.82	20.99	2.48	3	1.86	1.16
2011	0	0	15.15	37.25	35.58	30.94	4.84	4.28	2.91
2012	0.5	11	6.11	18.12	21.63	20.82	13.02	1.35	0.72
2013	0	0.95	31.08	26.37	56.93	42.9	22.15	6.4	0.57

Table 16. Estimated fall spawner numbers-at-age (thousands) of Atlantic herring from the standardized acoustic survey.

	Age (years)											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1994	1672	2157	4442	201387	61956	33090	17255	2309	0	12	1918	326198
1995	386	12349	22326	11645	50030	9306	15773	23592	1762	767	868	148803
1996	50815	225769	241001	163904	21951	72902	16442	9671	4046	961	1405	808868
1997	0	66808	306768	200366	69384	8383	32111	9572	8225	3820	1304	706741
1998	2013	66600	190598	74419	45341	27959	5228	22791	3178	5052	4298	447477
1999	3843	59703	308283	191388	63421	32461	15972	2502	4774	4719	819	687887
2000	79504	55502	127954	188246	137871	40048	13236	6624	2368	3731	2288	657371
2001	83592	96857	32803	12930	10047	8640	1367	817	214	125	76	247468
2002	1227	166012	32158	31345	20360	27785	16128	4708	689	93	144	300647
2003	611	50128	255384	67523	19953	5758	6693	7959	1644	699	0	416354
2004	0	29536	69627	53080	10888	2238	63	278	0	734	0	166443
2005	21	29089	62771	253848	138439	31786	10934	4140	4135	1762	1939	538863
2006	0	220736	75112	43095	75211	50965	7324	1405	802	543	0	475193
2007	0	78619	147272	42055	19589	11057	7524	139	712	571	0	307537
2008	8	71725	90952	50361	7565	4737	5166	3304	517	229	0	234565
2009	0	71658	112022	80911	39829	5644	1569	833	134	37	0	312637
2010	0	34571	107009	113652	94280	25025	4023	1292	213	213	0	380279
2011	0	28195	41020	86202	68114	51617	22620	4808	2908	1077	0	306561
2012	0	200	244044	118617	107531	52523	18041	1794	2958	190	0	547475
2013	0	3969	18802	170092	69744	97888	40839	10830	7674	11321	0	431158
2014	16	136216	62631	18752	88618	44387	38367	22382	7818	1541	0	420727

Table 17. Multi-species trawl survey fall-spawning herring mean numbers per tow at age (from Surette et al. 2016b). The values represent the median from MCMC posterior distributions for each year and age.

	Age (years)										
Year	1	2	3	4	5	6	7	8	9	10	11+
1994	0.95	0.83	1.97	23.75	7.89	12.87	16.87	6.41	2.69	7.84	0.14
1995	0.72	1.80	8.04	6.09	21.07	5.90	6.26	7.14	0.76	1.65	1.62
1996	0.65	2.13	0.89	2.93	0.89	3.07	1.07	1.40	0.73	0.30	0.30
1997	4.01	18.52	17.60	7.73	17.72	5.54	11.14	3.00	3.29	2.25	0.88
1998	3.22	1.65	1.23	6.10	1.35	3.37	1.21	1.87	0.50	0.75	0.55
1999	5.09	11.42	3.56	5.16	2.77	1.18	1.76	0.98	0.79	0.37	0.13
2000	4.39	6.49	7.12	11.70	10.53	3.91	0.91	2.25	0.68	0.59	0.04
2001	4.30	24.29	16.27	8.78	9.21	10.57	4.73	2.15	1.15	0.75	0.56
2002	1.88	10.78	9.93	18.38	7.82	6.19	5.44	1.73	0.90	0.46	0.32
2003	9.19	0.72	7.35	21.40	19.19	9.06	5.35	5.47	0.84	0.62	0.34
2004	2.01	2.29	6.63	11.97	7.51	6.01	4.71	3.19	2.08	0.42	0.22
2005	0.69	3.00	10.79	61.36	95.06	21.79	12.37	10.07	5.27	4.14	1.09
2006	20.20	14.34	8.15	23.28	15.12	21.71	8.27	5.27	0.67	0.44	0.59
2007	3.27	23.33	54.96	9.67	16.44	12.76	16.22	4.81	4.04	1.74	0.83
2008	3.33	16.36	13.45	17.72	1.87	5.91	3.68	2.94	1.33	1.81	0.25
2009	2.56	19.52	30.87	30.55	19.87	4.64	4.46	3.03	2.88	0.10	0.06
2010	0.63	17.51	19.59	32.14	20.47	20.51	2.84	1.85	1.73	1.01	0.11
2011	0.53	34.96	10.64	35.60	40.34	25.05	12.48	5.39	1.82	2.66	0.03

Table 18. Maturity ogive (proportion mature at age) for fall spawning Atlantic herring from NAFO Div. 4T.

Age (years)	Proportion mature
2	0
3	0
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11+	1

FIGURES

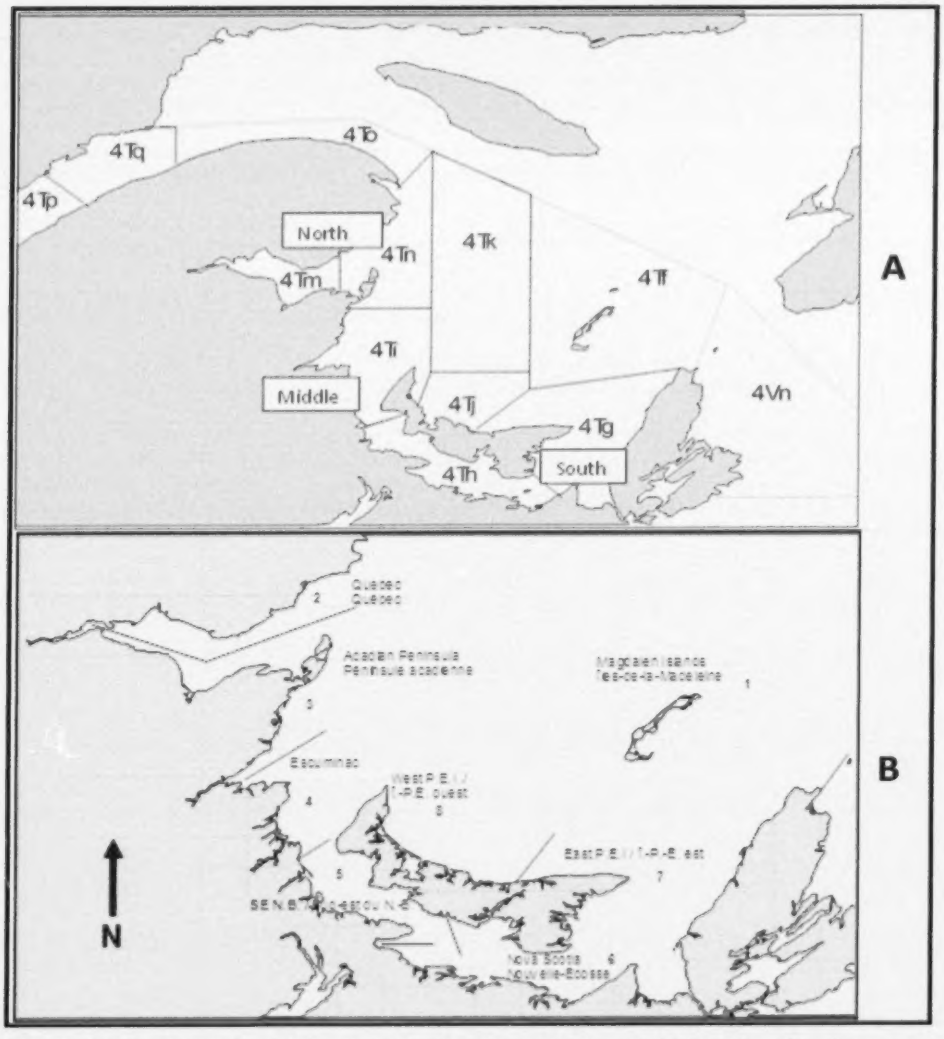

Figure 1. Atlantic herring Northwest Atlantic Fisheries Organization (NAFO) Div. 4T unit areas (panel A) and geographic areas used in the telephone survey of the herring gillnet fishery (panel B).

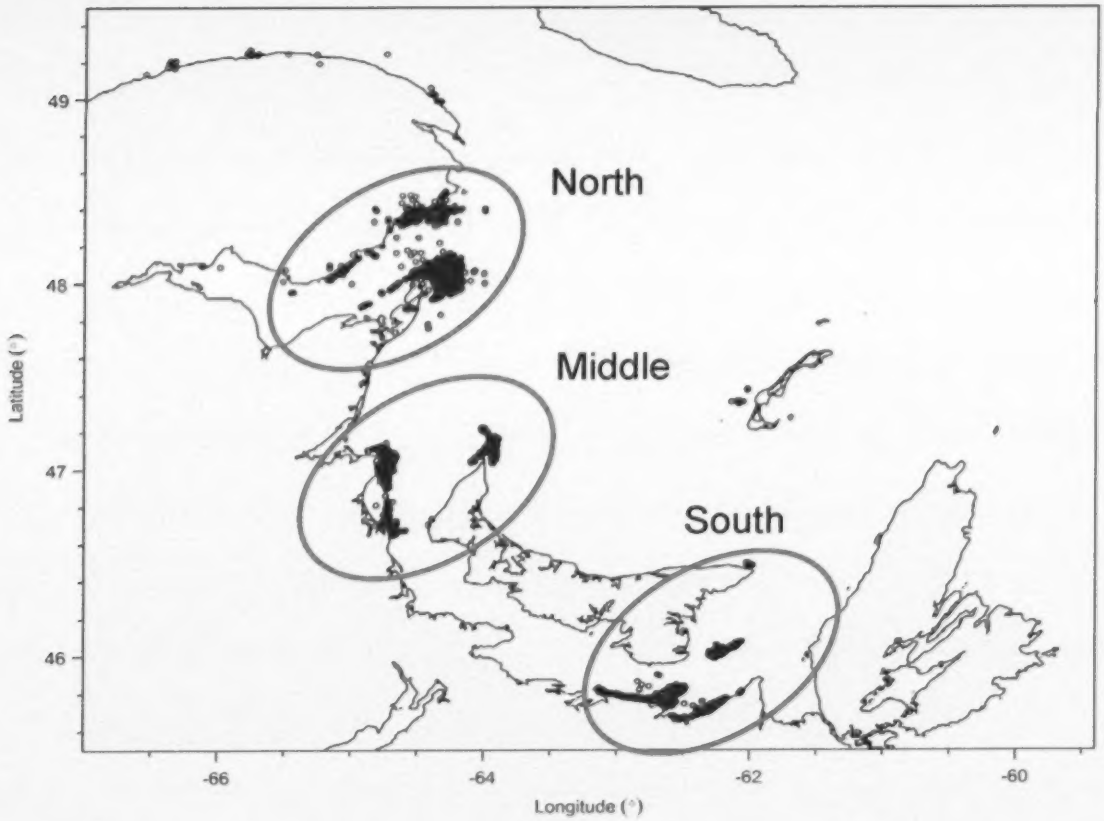

Figure 2. Geographic locations of fall herring spawning grounds in the southern Gulf of St. Lawrence and their grouping into three putative populations (north, middle, and south) for assessment and management purposes. The points represent locations of industry acoustic surveys in all area and fishing locations are from logbooks for Gaspe harvesters in the North region.

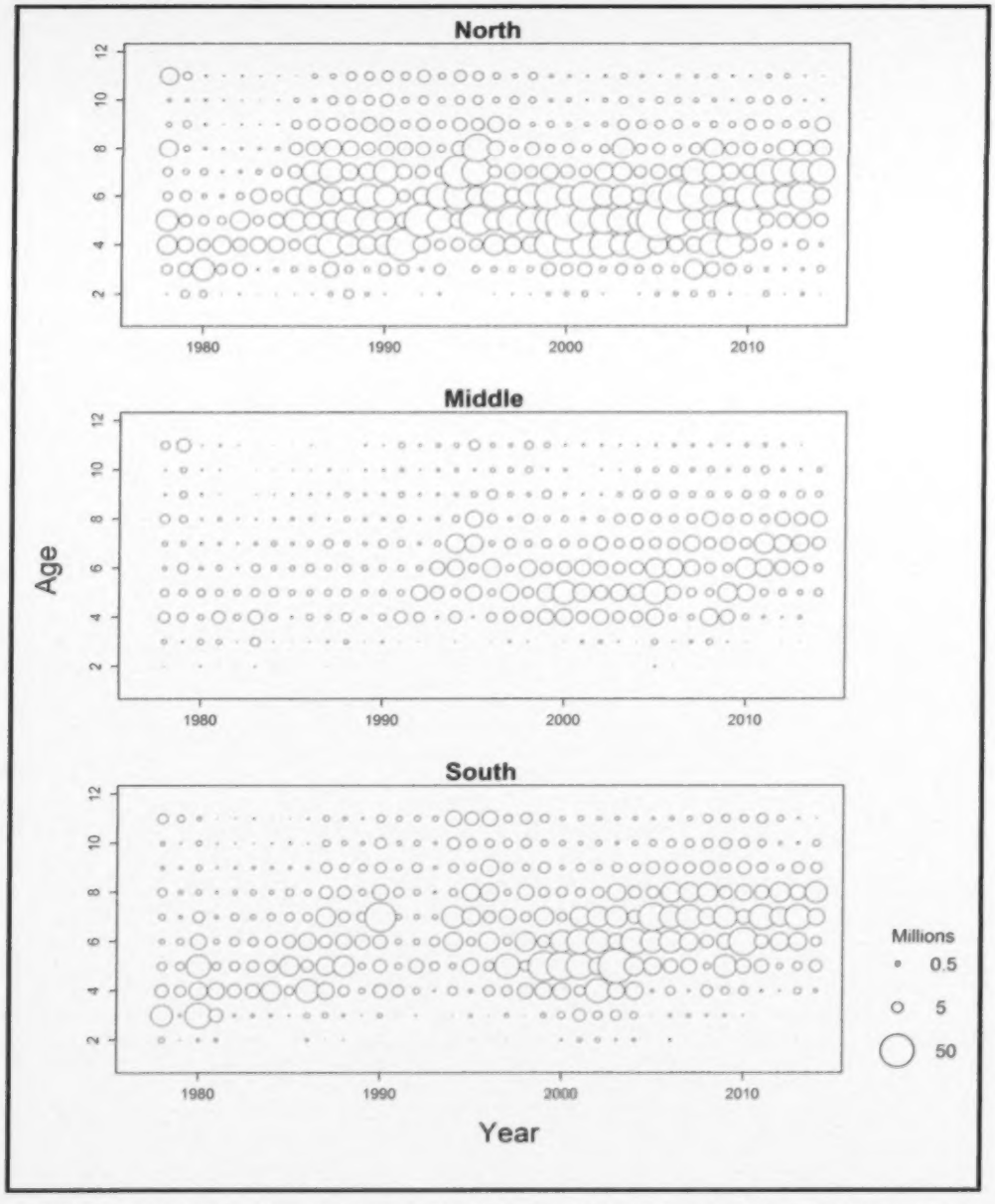

Figure 3. Bubble plots of fishery catch-at-age of fall spawner Atlantic herring by region for mobile and fixed gears combined, 1978 to 2014. The area of the bubble is proportional to the number of fish in the catch at age. The catches indicated at age 11 represent catches for ages 11 and above.

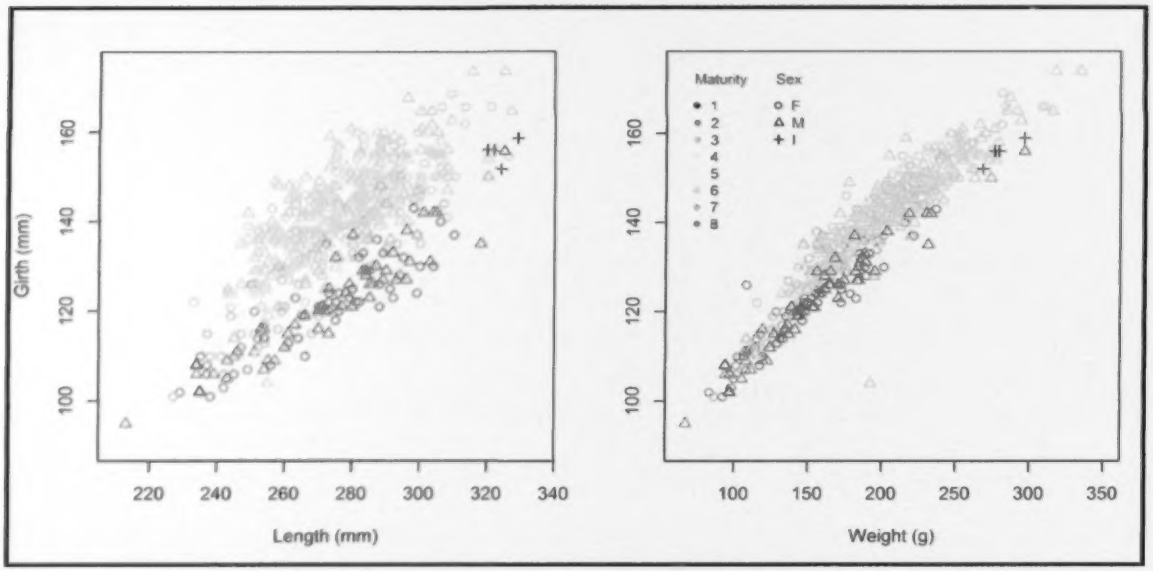

Figure 4. Relationship between individual Atlantic herring length (left) or weight (right) and girth, as a function of maturity stage and sex. The maturity stages are as follows: 1-immature, 2-maturing, 3-maturing(1), 4- maturing(2) , 5- ripe, 6-spawning, 7-spent , 8-resting. The sexes are F-female, M-male and I-undetermined.

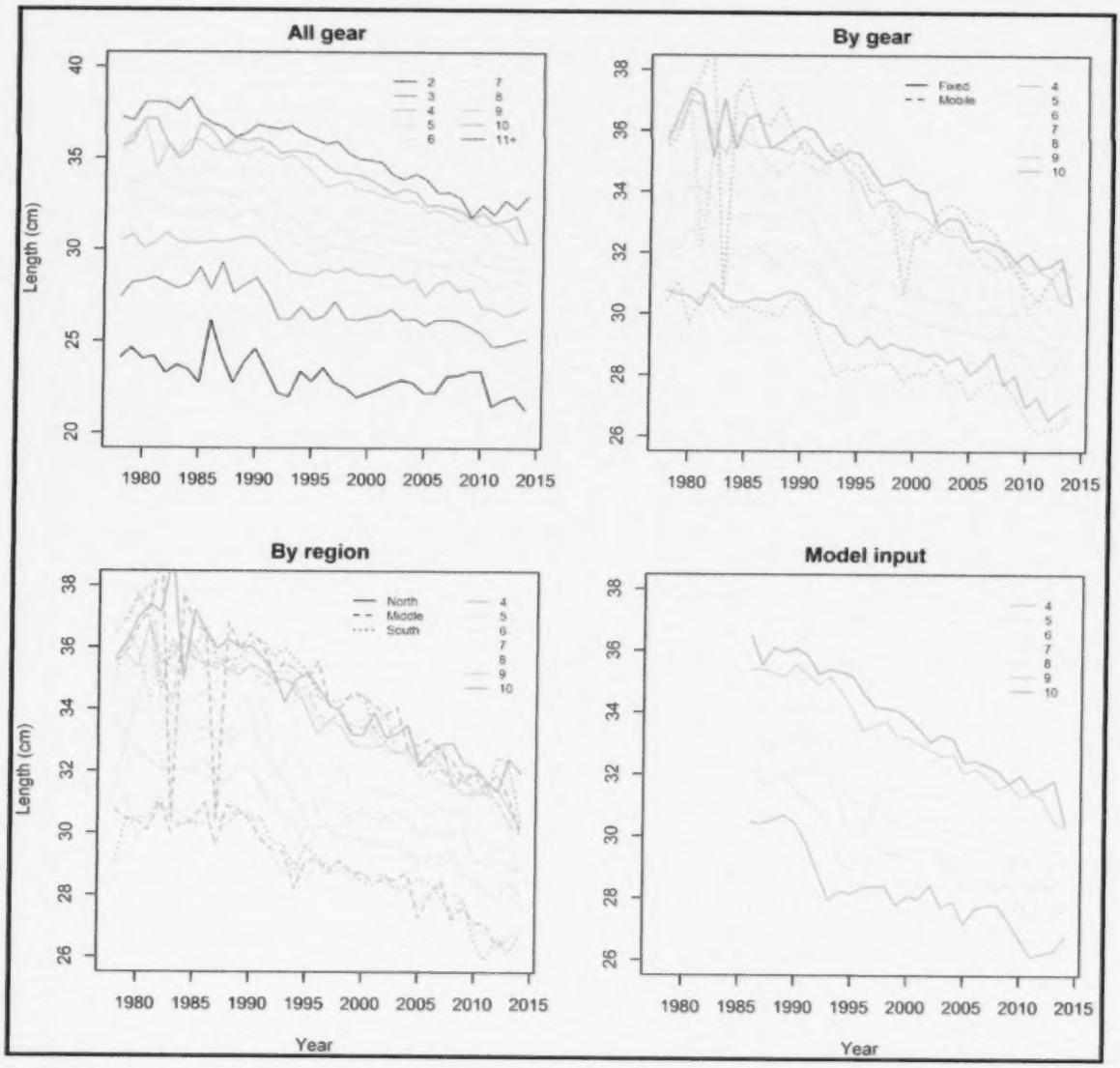

Figure 5. Trends in mean length-at-age (in late summer and early fall) of fall spawning Atlantic herring in the southern Gulf of St. Lawrence fisheries by mobile and fixed gear fisheries combined (top left), by gear (top right) and by region for fixed gear only (bottom left). The bottom right panel shows the values from the mobile gear fishery which are considered more representative of length at age of the population.

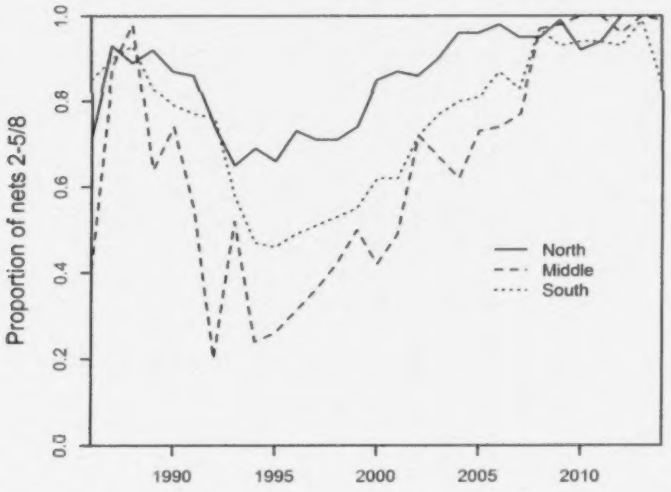

Figure 6. The proportions of gillnets in the fixed gear fall fishery that were $2^{5}/_{8}$ inches mesh size (minimum size since 1993), for the three regions in the southern Gulf of St. Lawrence, 1986 to 2014. It is assumed that the other nets used in the fishery were $2^{3}/_{4}$ inches mesh.

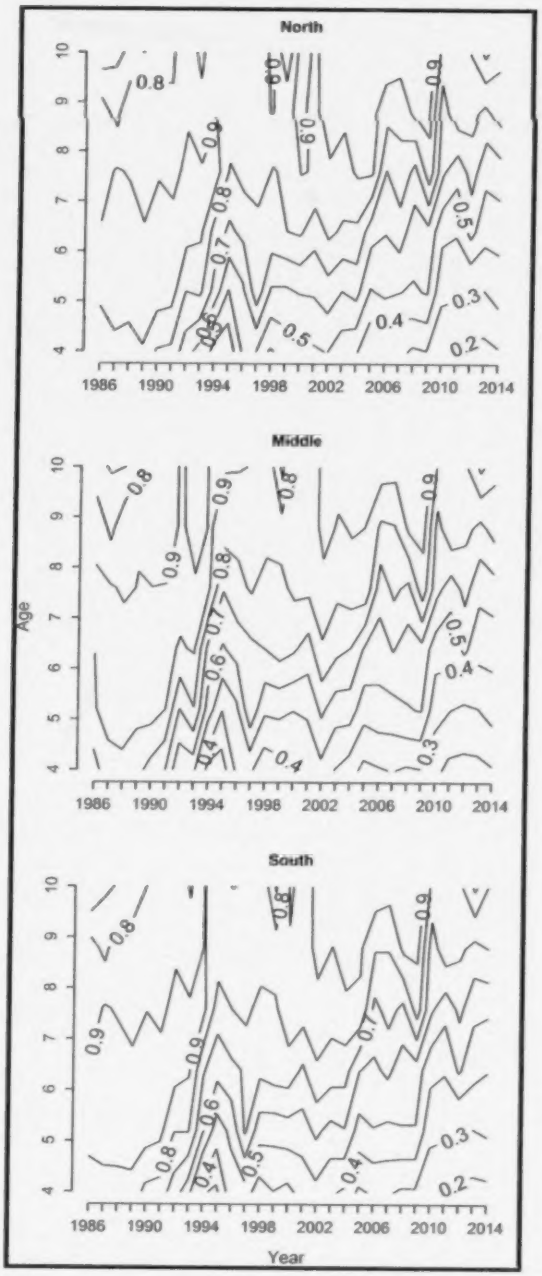

Figure 7. Contour plots of relative selectivities as a function of age and year in the fixed gear fall herring fishery by region, 1986 to 2014. These values were derived from the annual proportion of nets by mesh size by region (Fig. 5) and the selectivity ogives of the mesh sizes at age.

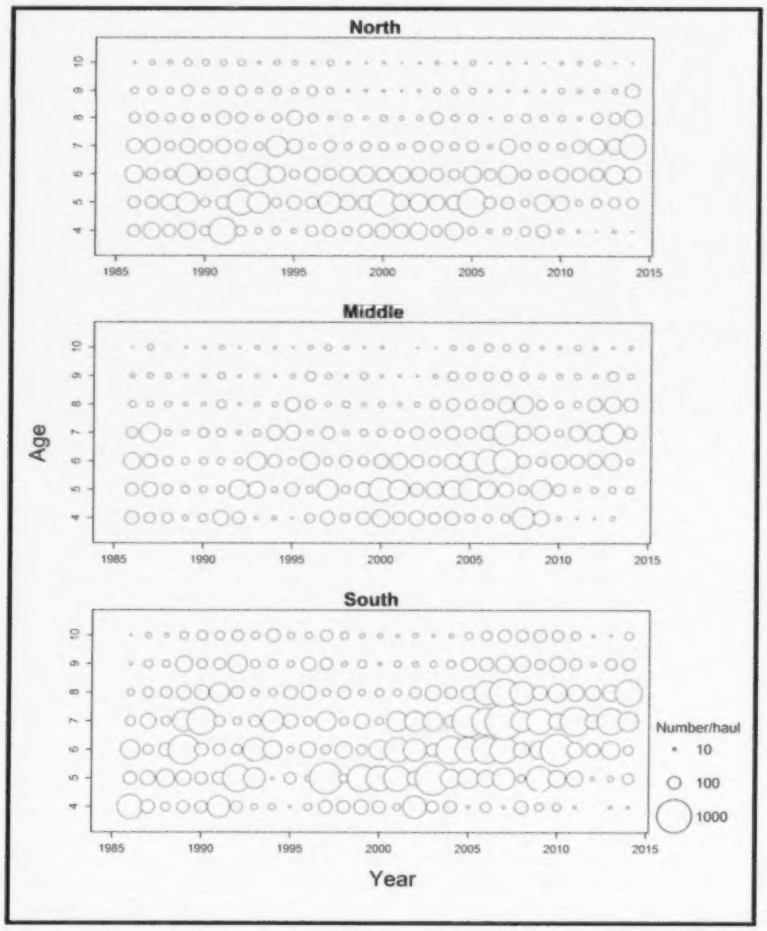

Figure 8. Bubble plots of gillnet catch-per-unit-effort indices (number per net haul) of fall spawner Atlantic herring at age (ages 4-10), from the north (upper panel), middle (middle panel) and south (lower panel) regions of the southern Gulf of St. Lawrence, 1986 to 2014.

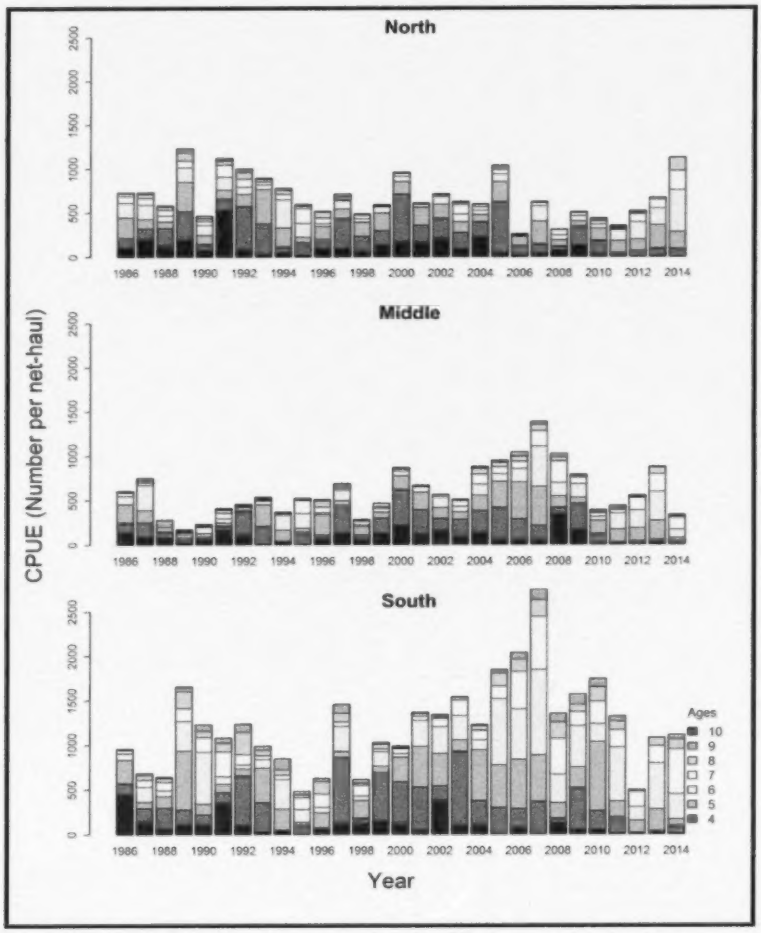

Figure 9. Stacked bar plots of gillnet catch-per-unit-effort indices (number per net haul) of fall spawner Atlantic herring at ages 4 to 10 years from the north (upper panel), middle (middle panel) and south (lower panel) regions of the southern Gulf of St. Lawrence, 1986 to 2014.

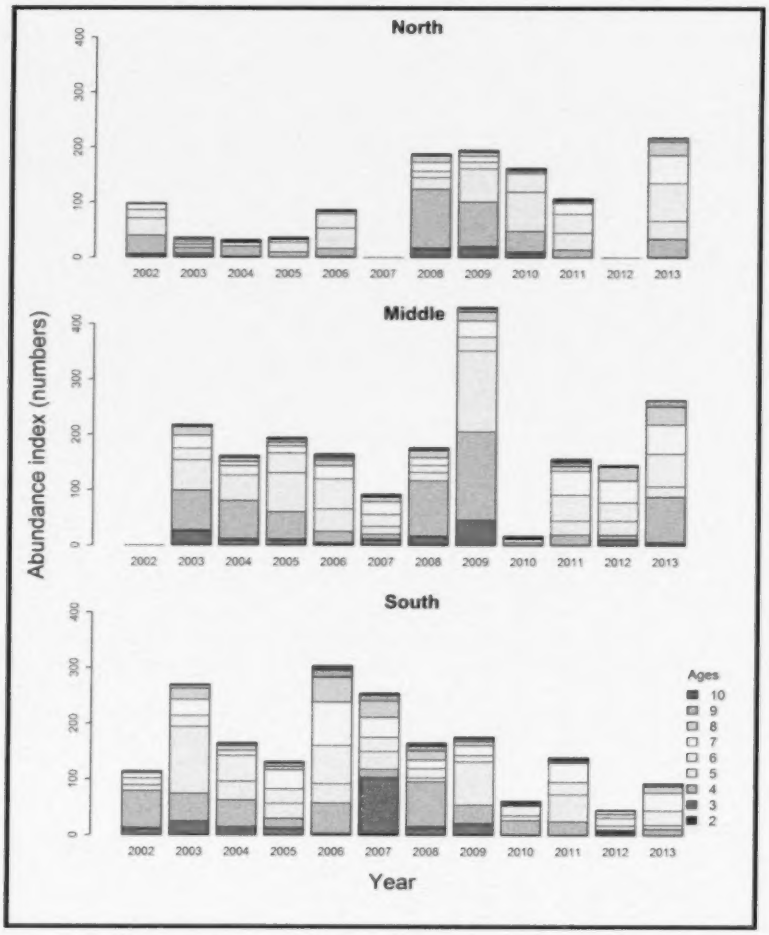

Figure 10. Stacked bar plots of experimental net indices of abundance at age (2 to 10 years) of fall spawner Atlantic herring, from the north (upper panel), middle (middle panel) and south (lower panel) regions of the southern Gulf of St. Lawrence, 2002 to 2013. No data are available from the North region in 2007 and 2012 and from the Middle region in 2002.

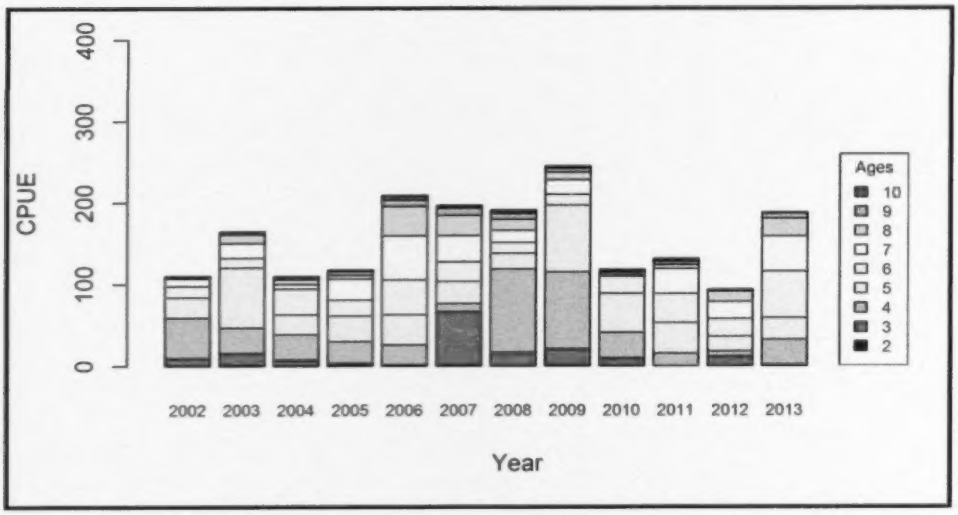

Figure 11. Stacked bar plots of experimental net indices of abundance (numbers) at age (2 to 10 years) of fall spawner Atlantic herring for NAFO 4T as a whole calculated as averages of region specific values weighted by regional catch at age, 2002 to 2013.

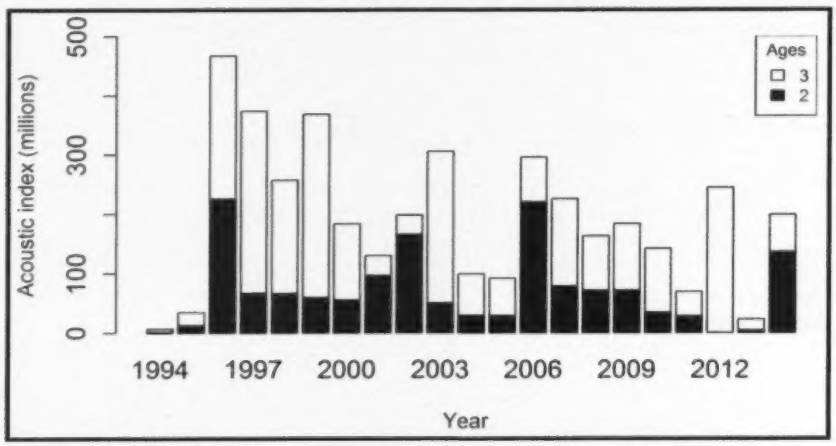

Figure 12. Fall spawner acoustic survey juvenile indices (in millions of fish, for ages 2 and 3) of fall spawner Atlantic herring of the southern Gulf of St. Lawrence, 1994 to 2014.

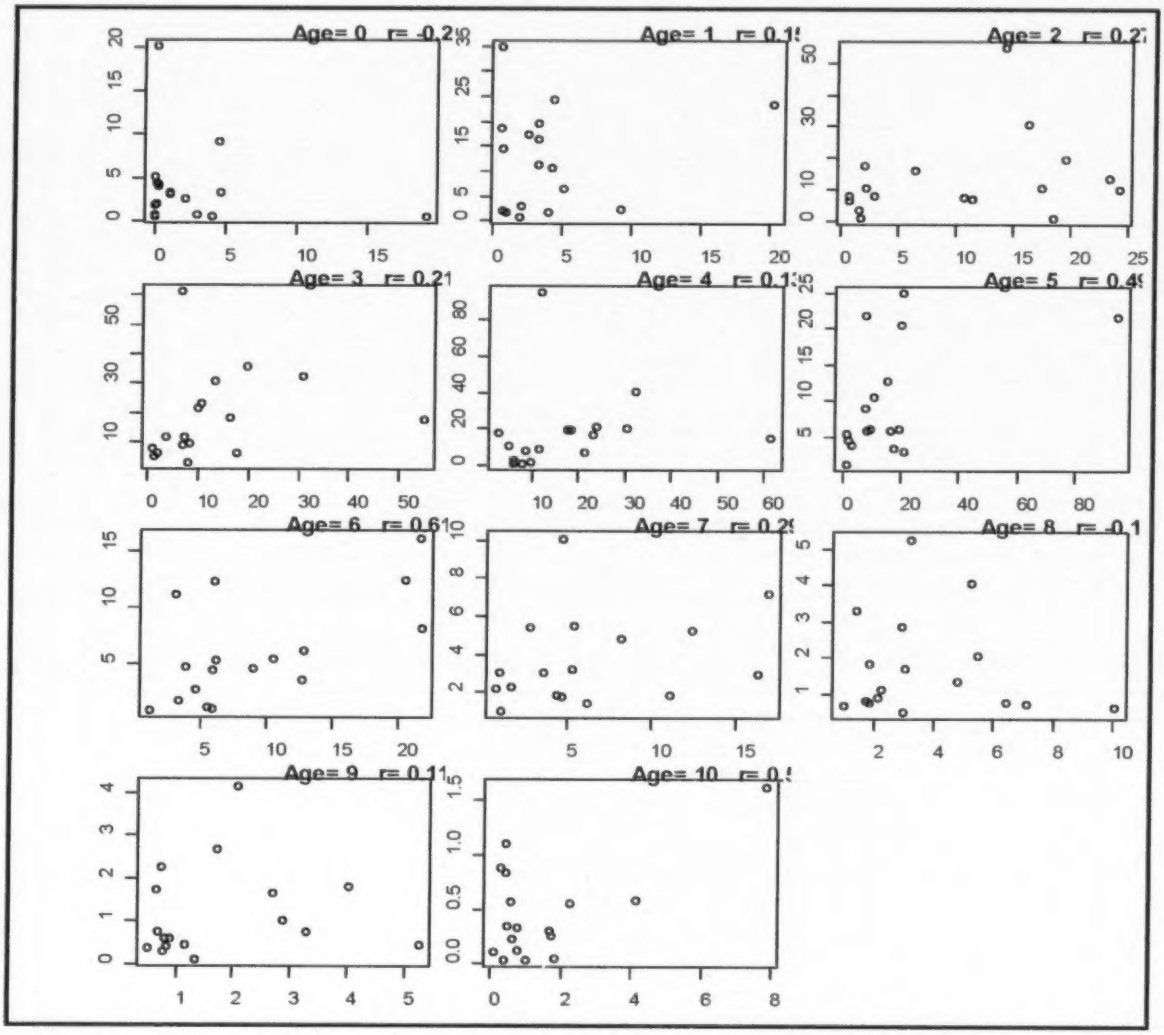

Figure 13. Bivariate plots of the multispecies bottom trawl survey abundance index values (numbers per tow) of fall spawner Atlantic herring of the southern Gulf of St. Lawrence for a given age in one year and the subsequent age in the following year, with separate panels for each initial age. The intra-cohort adjoining-year correlation (Pearson r) values are indicated above each plot.

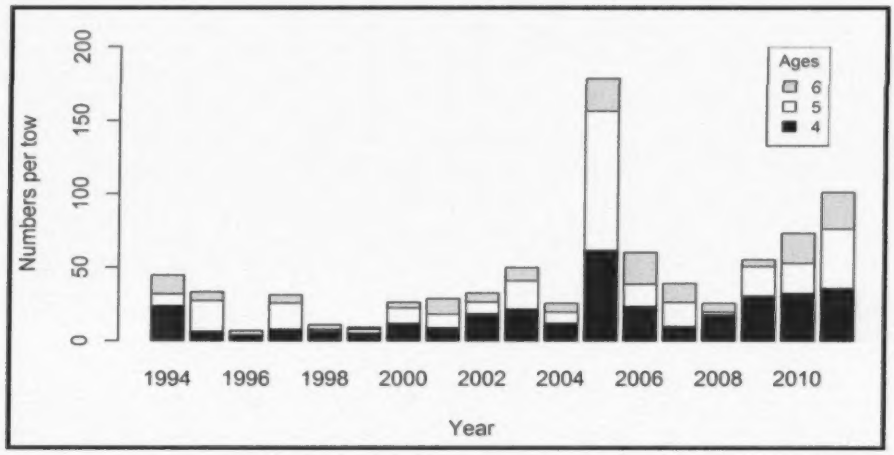

Figure 14. Multispecies bottom trawl survey abundance index (number of fish per standardized tow) for fall spawner Atlantic herring ages 4 to 6 years, 1994 to 2011.

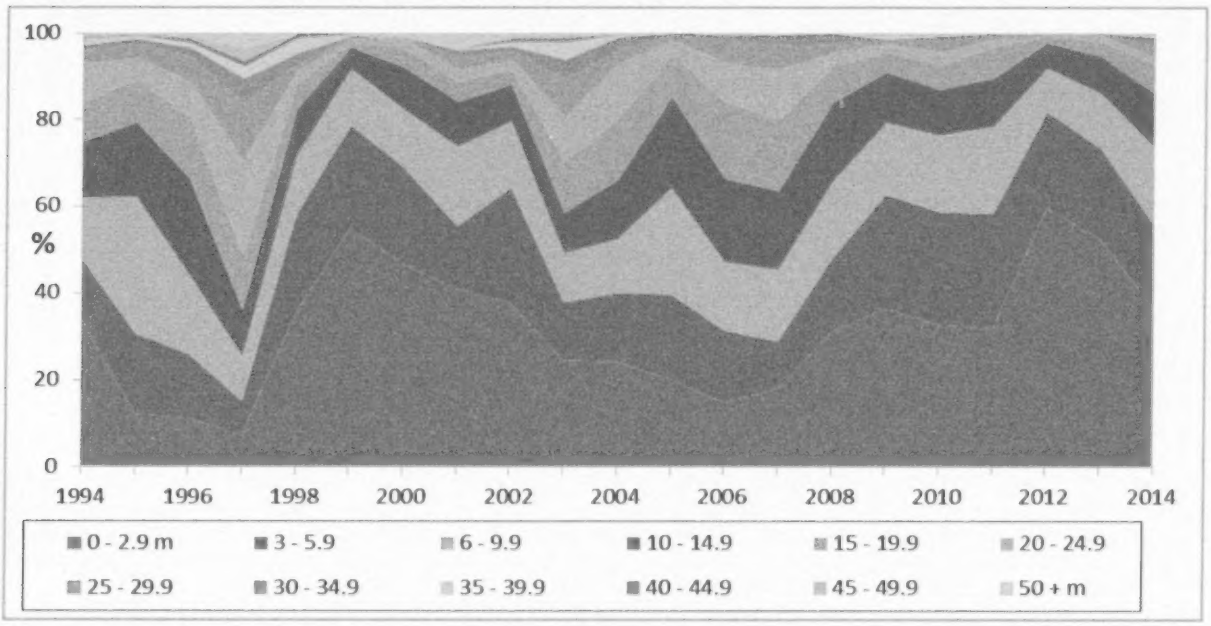

Figure 15. Percentage of estimated biomass of Atlantic herring by depth layer (0 m is the bottom) based on the acoustic survey of the Chaleur-Miscou area of the southern Gulf of St. Lawrence.

APPENDICES

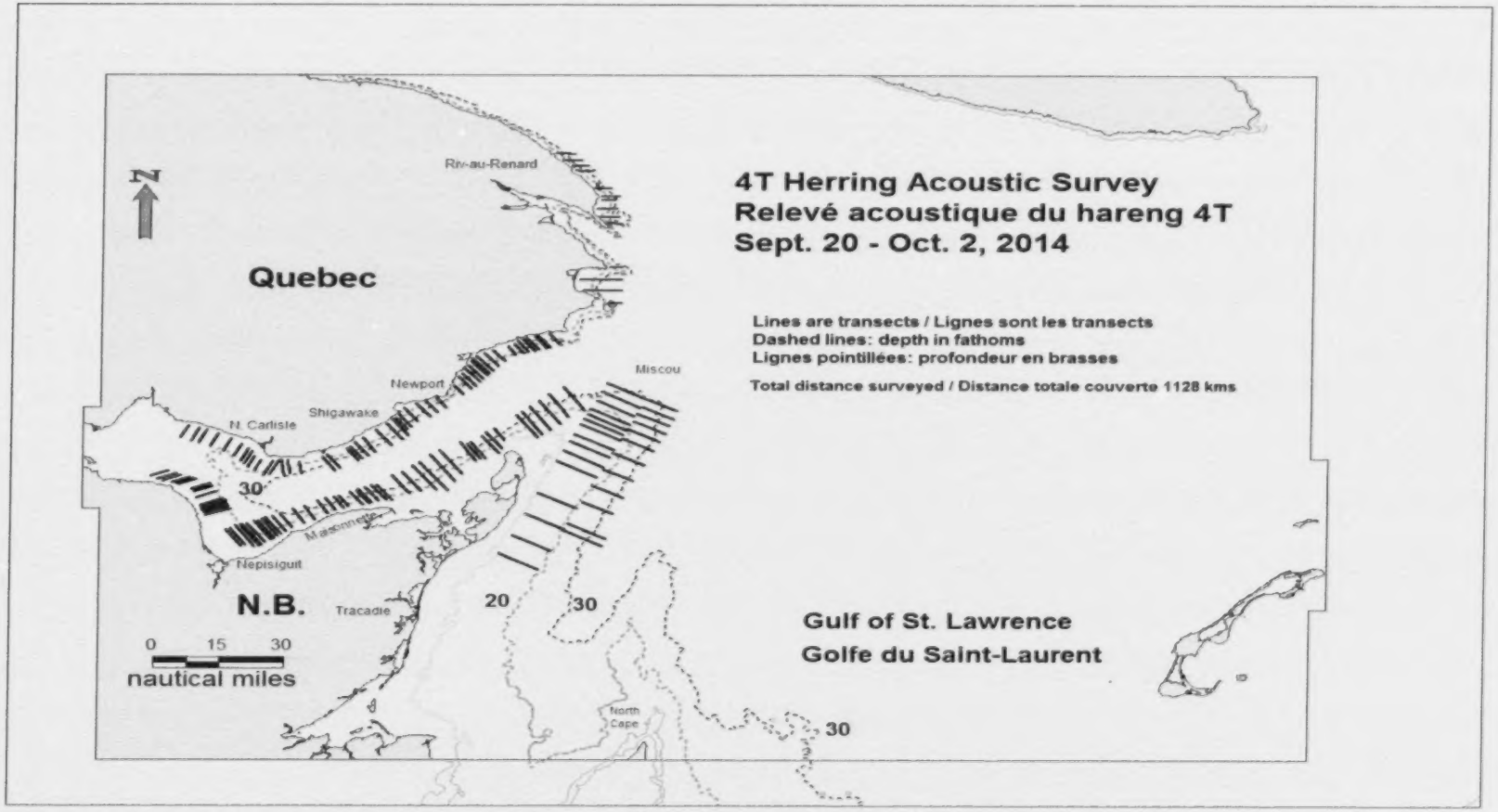

Figure A1. Surveyed transects covered during the 2014 acoustic survey (lines).

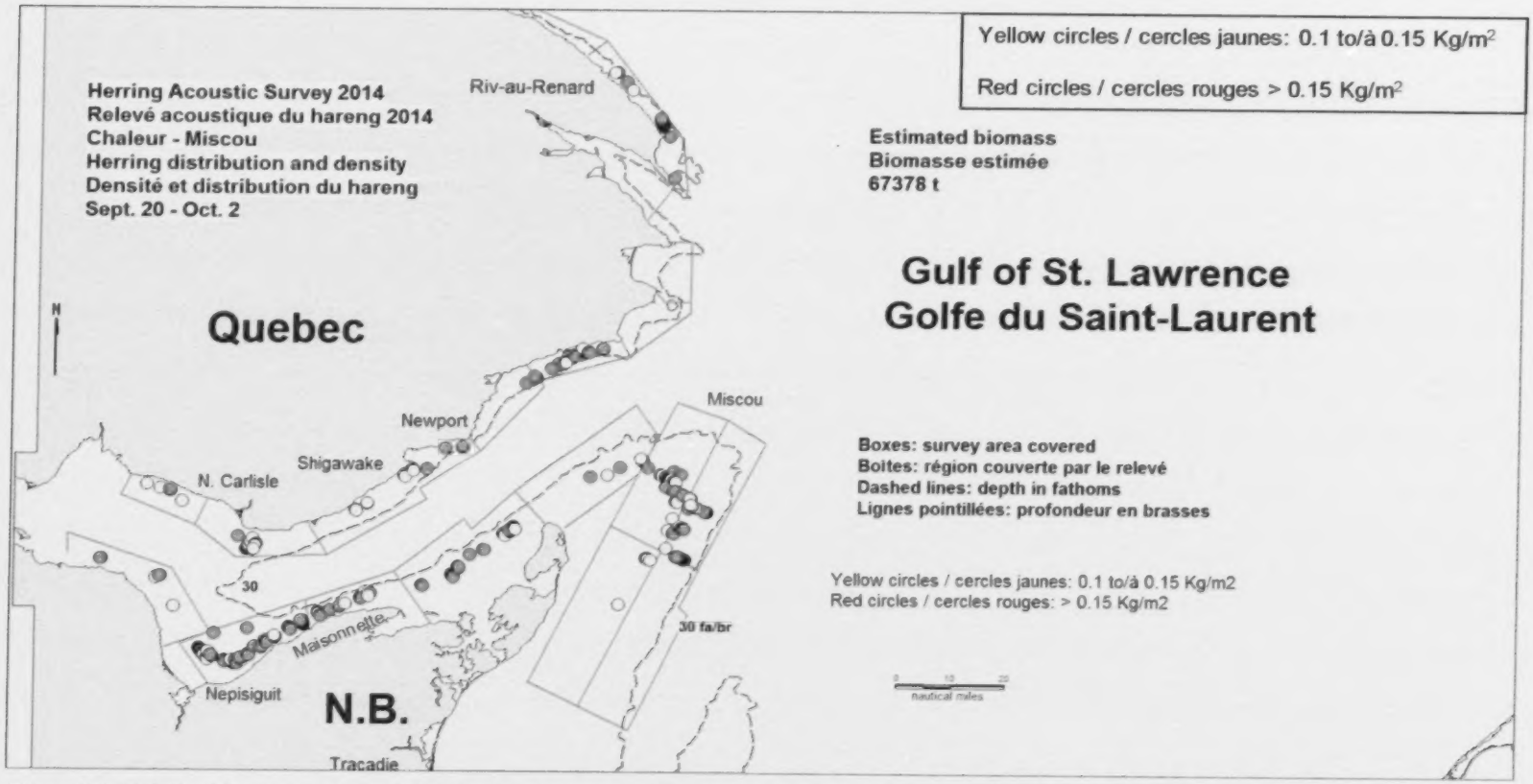

Figure A2. Relative biomass values of Atlantic herring detected in the Chaleurs-Miscou area (circles) during the 2014 acoustic survey.

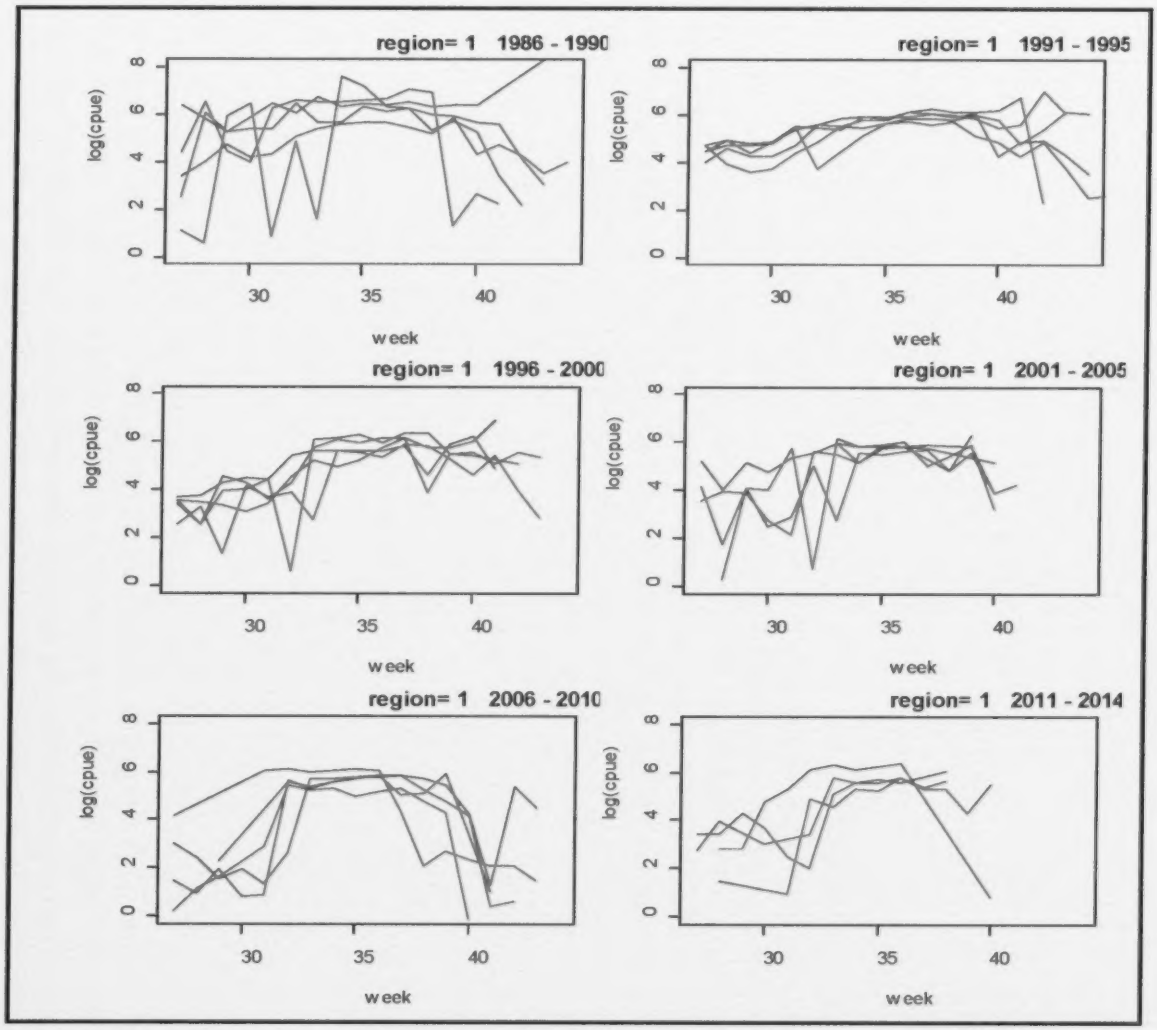

Figure A3a. Trends in log catch-per-unit-effort (log(cpue)) as a function of week for five-year blocks in the North (region = 1). Each line in each panel is the CPUE trend for a single year.

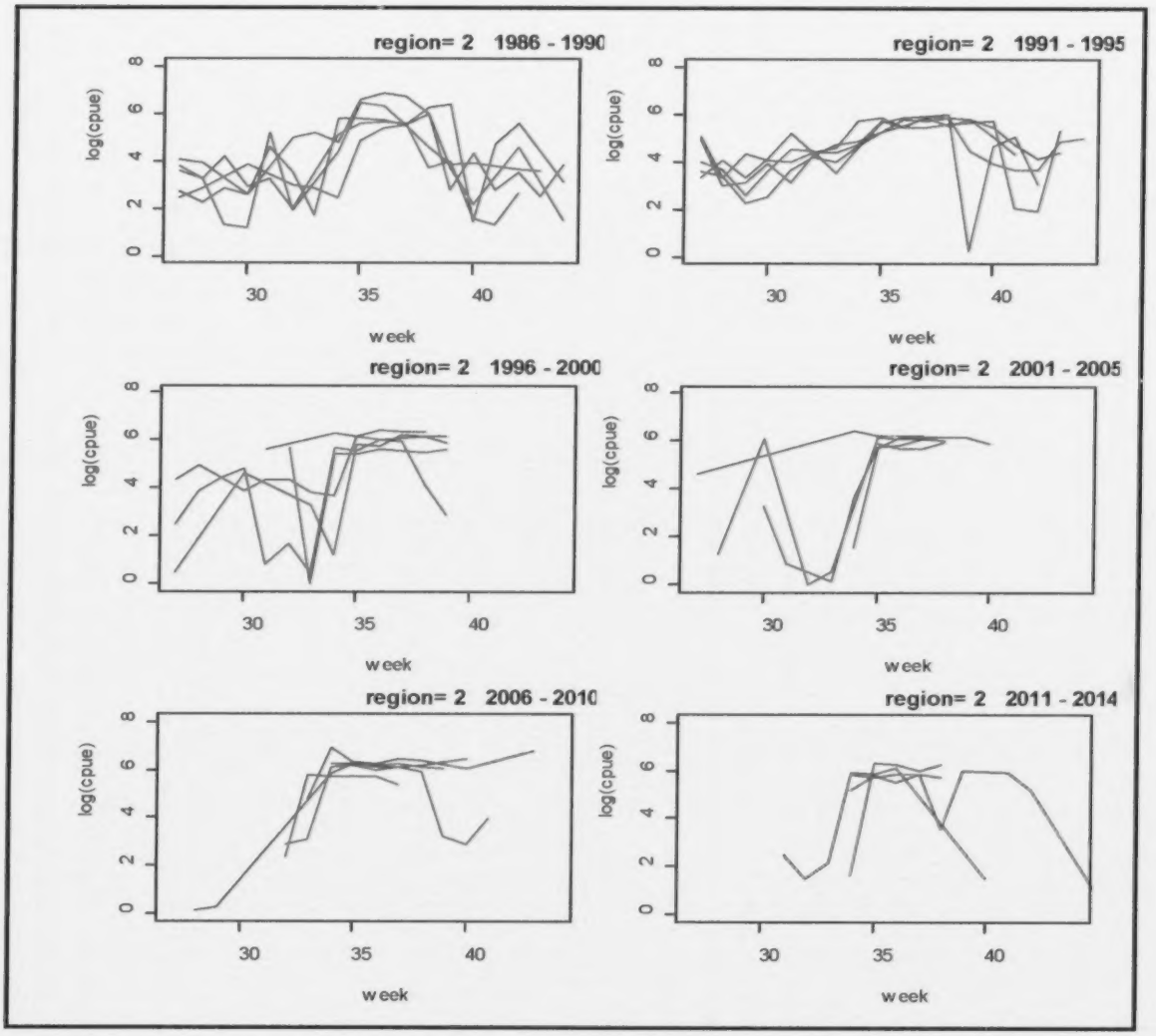

Figure A3b. Trends in log catch-per-unit-effort (log(cpue)) as a function of week for five-year blocks in the Middle (region = 2). Each line in each panel is the CPUE trend for a single year.

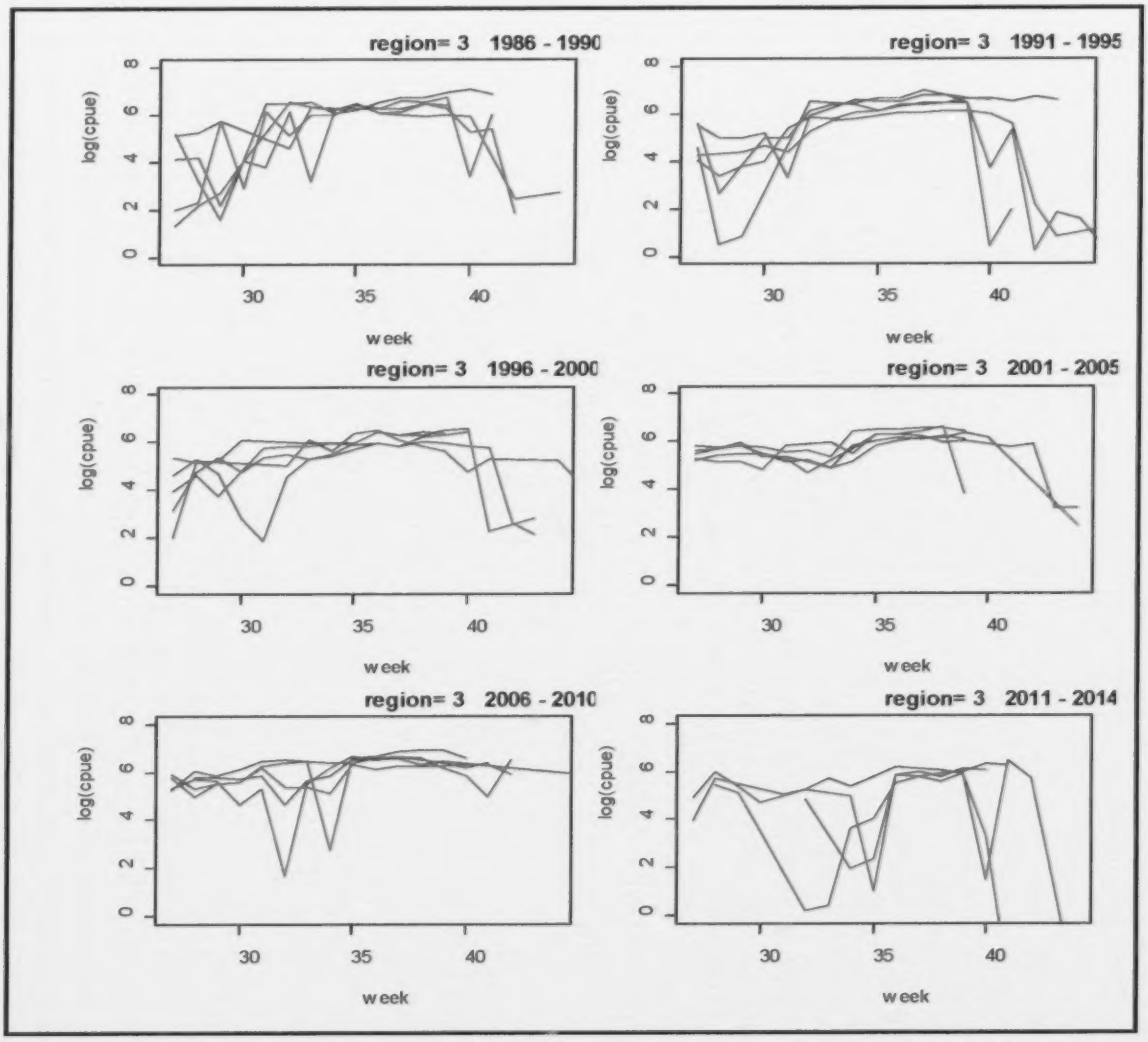

Figure A3c. Trends in log catch-per-unit-effort (log(cpue)) as a function of week for five-year blocks in the South (region = 3). Each line in each panel is the CPUE trend for a single year.

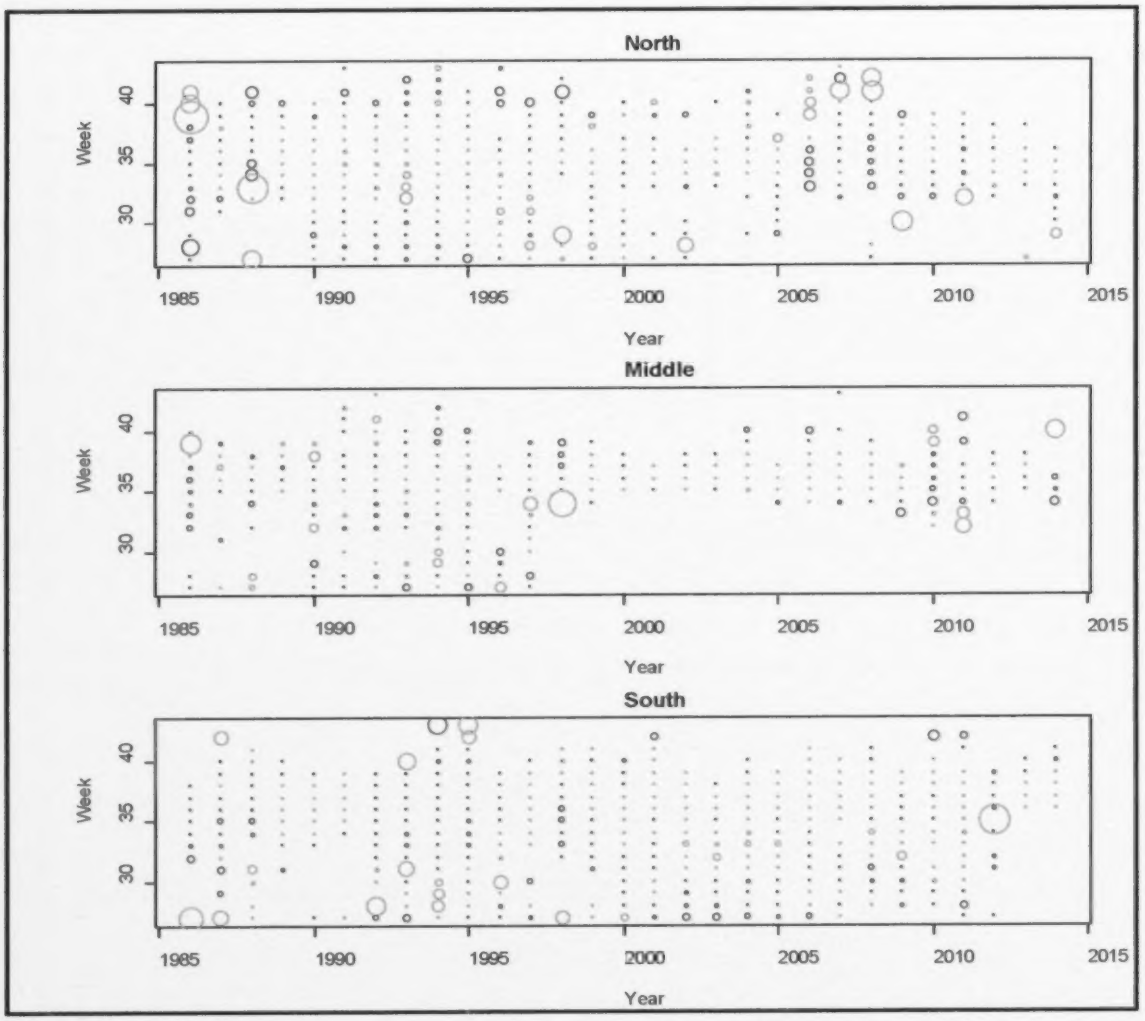

Figure A4. Residuals from the multiplicative general linear model of catch-per-unit-effort of fall spawner Altantic herring as a function of year and week for the North (upper panel), Middle (middle panel) and South (lower panel) regions of the southern Gulf of St. Lawrence. Positive residuals are in blue, negative in red, and the magnitude of the residuals is proportional to the size of the circle.